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STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITES HANDBOOK

A PRODUCT OF THE STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE PROGRAM COMMITTEE

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The Standardized UXO Technology Demonstration Site Program is a multi-agency undertaking coordinated by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the Engineer Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP) and Strategic Environmental Research and Development Program (SERDP). The objective of the Standardized Unexploded Ordnance (UXO) Technology Demonstration Site Program is to provide the procedures, materials and technical assistance required to establish standardized sites in geographical areas that have unique features that may interfere with the ability of a given technology to detect and discriminate buried ordnance. This objective has two applications. First, it provides the UXO technology developer(s) with standardized research and development sites for sensor/system technology research, testing and demonstration in a variety of geographical locations. It also provides guidance on establishing a "quality-control" site to check on a technology's ability to operate effectively in a specific area prior to restoration efforts. The objective of this document is to establish the protocols need to construct, operate, and maintain a Standardized UXO Technology Demonstration Site.

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SECTION 1. INTRODUCTION

1.1 BACKGROUND

Advancements in unexploded ordnance (UXO) detection and discrimination technologies are necessary to support the operation, restoration, or transfer of the DoD's target impact areas, firing and test ranges. Past experience has shown that UXO characterization technologies can be affected by variations in site terrain, geology, vegetative cover, and weather conditions: limiting the ability or confidence in a given technology to detect buried ordnance. Therefore, the establishment of standardized UXO technology demonstration sites is necessary to gather data on sensor and system performance, and to compare results between emerging or existing technologies.

Other products developed in support of this program include a standardized target repository for site development, a technology scoring matrix to document system performance, and a variety of technology transfer and marketing materials.

The Standardized UXO Technology Demonstration Site Program is a multi-agency undertaking coordinated by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Army Environmental Quality Technology Program, Environmental Security Technology Certification Program (ESTCP) and the Strategic Environmental Research and Development Program (SERDP).

1.2 OBJECTIVE

The objective of the Standardized UXO Technology Demonstration Site Program is to provide the procedures, materials and technical assistance required to establish standardized sites in geographical areas that have unique features that may affect the ability of a given technology to detect and discriminate buried ordnance. The program provides the UXO technology developer(s) with standardized research and development sites for sensor/system technology research, testing and demonstration in a variety of geographical locations. It also provides guidance on establishing a "quality-control" site to check on a technology's ability to operate effectively in a specific area prior to restoration efforts.

The objective of this document is to establish the protocols needed to construct, operate, and maintain a Standardized UXO Technology Demonstration Site.

1.3 STANDARDIZED SITES

To satisfy both the research and development community and the technology demonstration community, a standardized site consists of four areas: Calibration Lanes, a Ground Truth Test Pit, a Blind Test Grid, and an Open Field Site. The Calibration Lanes allow demonstrators to test their equipment, build a site library, document signal strength, and measure the effects of

site-specific variables. The Ground Truth Test Pit is a 2-cubic meter area, adjacent to the Calibration Lanes, in which the demonstrators may position targets that are of specific interest in their hardware or software development programs. The Blind Test Grid allows the characterization of sensors independent of navigation or site coverage effects. The Open Field Site allows testing of entire integrated systems in realistic field conditions including sensor, platform, navigation system and processing.

1.4 PROGRAM GOALS

The Standardized UXO Technology Demonstration Site Program is a collaboration of several organizations. Using the experience and expertise of all participants, this program will ensure that critical UXO technology performance parameters such as detection capability, false alarm rates, discrimination, reacquisition, and system efficiency are determined with standardized test methodologies, procedures, and facilities.

SECTION 2. GUIDANCE FOR ESTABLISHING A STANDARDIZED UXO SITE

2.1 INTRODUCTION

The primary purpose of this document is to establish the protocols needed to construct, operate and maintain a standardized UXO research, development, test and evaluation (RDT&E) site. During active site removal actions, quality control sites can be established based on these RDT&E protocols, but tailored to fit the specific needs of the area to be cleared.

The following information on "Site Selection" and "Roles and Responsibilities" provides an outline view of the selection process and the management and oversight structure for administering the local test sites and the overall UXO program. Detailed information on these same subjects is provided beginning in section 3.

2.2 SITE SELECTION CRITERIA

The RDT&E site selection and development are based on the needs of both the research and development and technology demonstration communities to establish standardized test sites in areas with varying geological features, soil types and climatic conditions. The site requirements are provided as follows:

a. test sites will be located on U.S. Government installations.

b. test area should have minimum impact on other installation activities/operations.

c. area should be controlled with limited access to maintain integrity of the test site.

d. conditions should match the specific test requirements (type of soil [i.e., moist silty, dry sandy soils, moist clayey soils, etc.], electrical conductivity, magnetic susceptibility, etc.).

e. An area should contain low levels of metallic clutter.

f. The site must be able to accommodate these three test areas:

(1) Calibration Lanes/Ground Truth Test Pit - 0.2 hectare devoid of trees with flat topography. Detailed characterizations of the required topography of these sites can be found in paragraphs 4A.2.1 and 4B.2.1.

(2) Blind Test Grid - 0.4 hectare devoid of trees with flat topography. A detailed characterization of the required topography of this site is in paragraph 4C.2.1.

(3) Open Field Site - Minimum of 4 hectares, mainly clear of trees, where vegetation and topography vary. Paragraph 4D.2.1 provides additional information.

g. Geology should be known and be as consistent as possible throughout the site.

h. Land use restrictions relating to the proposed site must be identified.

i. Test areas cannot be under established aircraft ascending or descending flight paths.

j. Additional sites should be present that can be used later for Airborne Detection Systems.

k. Sources of electromagnetic interference (EMI) must be identified and documented.

l. Line-of-sight must be present to a survey control point.

m. A meteorological station must be established.

2.3 ROLES AND RESPONSIBILITIES

2.3.1 On-Site Project Manager

During the site selection process, potential host installations will identify a single on-site Project Manager. The on-site Project Manager is responsible for:

a. Attending and participating in all related programs, meetings, and events.

b. Assisting to identify potential locations to establish a Standardized UXO Technology Demonstration Site. This may require interviewing individuals, researching historic information about proposed sites, identifying environmental considerations, and obtaining existing Geographical Information System (GIS) information on geology and soil conditions.

c. Coordinating all local documents with the appropriate parties (National Environmental Policy Act (NEPA), health and safety plans, work plans, facilities master planner, etc.).

d. Providing temporary storage area (secured) for inert standardized munitions targets being shipped to the site.

e. Coordinating and providing the oversight needed for constructing the Standardized UXO Technology Demonstration Site.

f. Obtaining clutter items. (Clutter can be range scrap metal, salvaged scrap metal, old weapon clips, cartridge cases, etc. (app A)).

g. Obtaining standardized targets. (section 4.5).

h. Providing contract support if such support is required, i.e., UXO clearance.

i. Providing secure temporary storage space for demonstrator equipment during the testing. Suggested size is 6 by 12 by 4 meters with a 2-meter (minimum) wide access door.

j. Providing a demonstrator work area (area to process data, phones, desk, bathrooms). The area should be within a reasonable distance of the test site. Another option is to provide a work trailer at the site.

k. Establishing a written agreement (Memorandum of Understanding (MOU)) between AEC and the host installation/military organization to construct, maintain and manage the Standardized UXO Technology Demonstration Site until the program is completed. A sample MOU is provided in Appendix B.

2.3.2 AEC Program Manager/ATC/ERDC Project Manager's Responsibilities:

a. Providing program oversight and funding to develop and closeout the test site.

b. Attending and participating in all related programs, meetings, and events.

c. Providing technical support.

d. Providing a Standardized UXO Technology Demonstration Site Handbook to the on-site Project Manager. The handbook outlines the steps involved from field site selection, required documentation, site construction and maintenance procedures, and field test procedures.

e. Placing and recording the location of all the target items placed in the ground.

f. Establishing user fee accounts to charge the demonstrator and transfer funds to the Standardized UXO Technology Demonstration Site on-site Project Managers.

SECTION 3. DOCUMENTATION FOR SITE PREPARATION

3.1 INTRODUCTION

This section describes the site preparation documentation that is required, identifies who is responsible for generating and reviewing the documents, and identifies who is responsible for target documentation and test data management.

3.2 MEMORANDUM OF UNDERSTANDING (MOU)

The ATC Project Manager drafts the MOU that establishes the written agreement between AEC and the host installation. The MOU (app B) outlines the roles and responsibilities of both parties. The AEC and on-site Project Managers will each keep a copy of the MOU.

3.3 SITE SELECTION DOCUMENTATION

This documentation consists of the collection of maps, notes, and historical documentation, compiled by the on-site Project Manager, and used for selecting the site. A copy of this information is forwarded to the Project Manager to be used when writing the program final report for ESTCP/SERDP.

3.4 SITE SUBMITTAL DOCUMENTATION

This is the local documentation required by the host installation/base to build the Standardized UXO Technology Demonstration Site. The documents typically required include project site submittal, internal waivers, memoranda, NEPA documentation, and any other site-specific information that may be required.

3.5 PRECONSTRUCTION DOCUMENTATION

The following documentation is typically required to construct the site:

a. Survey map of the area identifying the locations of each site component (Calibration Lanes, Ground Truth Test Pit, etc.).

b. Target design layout consists of a series of maps showing where target items will be placed in the Calibration Lanes, Blind Test Grid, and Open Field Site. Requests for these maps must be coordinated through AEC.

(1) Calibration Lanes/Ground Truth Test Pit. This document is kept by the on-site Project Manager and can be given to the demonstrator.

(2) Blind Test Grid. The Standardized UXO Technology Demonstration Site Ground Truth Committee keeps this document under strict control. It must be handled as **For Official Use Only - Competition Sensitive**.

(3) Open Field Site. The Standardized UXO Technology Demonstration Site Ground Truth Committee also keeps this document under strict control. It must be handled as **For Official Use Only - Competition Sensitive**.

c. Work, Health and Safety Plans will be in accordance with the host installation's health and safety requirements.

d. Occupational Health and Safety Administration (OSHA) standards may apply for civilian contractors engaged in UXO clearing and construction type work. Government agencies providing construction support and the demonstrator's field operations will comply with the host installation Job Hazard Analysis (JHA) and protocol work plans.

e. Contract documents will be prepared for UXO clearance, tree removal, and other construction activities.

3.6 OBTAINING STANDARDIZED CLUTTER ITEMS AND TARGETS

Information concerning the quantities of clutter and munitions that are placed in a test area is controlled as **For Official Use Only - Competition Sensitive** by AEC. This information will be provided to the on-site Project Manager, following the site selection and approval process.

a. Clutter items are the responsibility of the on-site Project Manager and can be obtained in one of two ways.

(1) They can be obtained locally using inert debris cleared from the test site areas.

(2) Alternative arrangements may also be made with the ATC Project Manager to provide clutter.

In either event, the items used as clutter must meet the requirements and be documented as described in Appendix A.

b. Obtaining standardized targets is also the responsibility of the on-site Project Manager. Two options are again available.

(1) Inert ordnance items may be located at the installation establishing the test site. These items need to be the same as those listed in Appendix A. Exceptions or substitutions must be coordinated with ATC and approved through AEC. Standard targets must be documented as described in Appendix A and degaussed following the procedures in Appendix C.

(2) ATC maintains a repository of standardized ordnance targets that can be loaned to standardized sites. All standardized targets are identical in fill, fuse, metallurgy, and configuration. ATC keeps track of all target items being shipped and loaned.

(3) In addition to the repository of standardized ordnance targets, a set of nonstandardized targets is also available. These targets are not in pristine condition. They may have different

configurations, fill, or fuses than the standardized targets. The nonstandardized targets may be bent, rusty, or have missing parts. Installations may also request that certain items not on the standardized list be placed in the field. These site-specific targets allow the installations the flexibility to gather information on technologies' capabilities against their specific concerns.

3.7 CONSTRUCTION DOCUMENTATION

a. If a UXO contractor is employed to clear the test area, it is the on-site Project Manager's responsibility to keep a copy of all contractor logs.

b. The on-site Project Manager is responsible for recording all field preparation activities with the exception of target placement and removal. Figure 3-1 should be used to create the daily construction logbook. The various construction activities are shown in paragraph 5.B of the figure. Each of these construction activities is described in later chapters of this document.

c. During the clutter and target placement phase of work, ERDC is responsible for photographing each item just prior to emplacement; filling out and certifying (by signature) the field target placement work sheet (fig. 3-2). The information on the placement sheet is also entered into a spreadsheet file (fig. 3-3) containing the following fields:

(1) Munition/Clutter Identification (ID) Number - It is extremely important that the ID numbers in this target location spreadsheet match precisely with the ID numbers recorded on the spreadsheet file containing the physical descriptions of targets (app A). This field will be used to link these two sets of data together.

(2) Field Test Area. Calibration Lanes (CAL), Blind Test Grid (B), Open Field Site (OF).

(3) Field Area/Grid Location. X-axis (number), Y-axis (letter).

(4) Ground Surface Depth. In meters, measured from highest point of the object to the ground surface.

(5) Dip. In degrees.

(6) Azimuth. Orientation in degrees.

(7) NAD83 UTM. Northing and Easting obtained from highest point of the object.

(8) Z depth relative to survey marker. Record in metric units.

(9) Target Placement Date.

(10) Res Mag.

(11) Target Removal Date.

(12) Field Photograph Link.

(13) Field Notes/Comments.

d. The on-site Project Manager is responsible for maintaining hard copies of all site construction records until the site is cleared of emplaced targets. Copies of these documents must be provided to the ATC/AEC Program Managers.

e. The ATC is also responsible for merging the target physical description and target location spreadsheets into a single file. Copies of this file are provided to the ATC/AEC Program Managers. This file must be handled as **For Official Use Only - Competition Sensitive**.

3.8 POST CONSTRUCTION DOCUMENTATION

Post construction documentation consists of all target emplacement records and maps. These data are reviewed by both ATC and AEC then forwarded to the Standardized UXO Technology Demonstration Ground Truth Committee in both hard copy and electronic (Excel® or Access®) formats.

a. Site Boundary Maps. Maps outlining the overall site boundaries (Calibration Lanes/Ground Truth Test Pit, Blind Test Grid, and Open Field Site). Boundary maps can be provided to the demonstrator.

b. Target Placement Map. Consists of three maps, Calibration Lanes, Blind Test Grid, and Open Field Site, showing the actual location of all the emplaced items. The Blind Test Grid and Open Field Site target placement maps are **For Official Use Only - Competition Sensitive**.

c. The spreadsheet file containing the target locations and descriptions is also **For Official Use Only - Competition Sensitive**.

d. Final Report. Completed by ATC/AEC Program Managers in SERDP format. The final report will be **For Official Use Only - Competition Sensitive**.

Note: The Standardized UXO Technology Demonstration Site Ground Truth Committee controls all post construction documentation.

DAILY CONSTRUCTION LOG

1. DATE: ______________________

2. LOCATION: ____________________

3. PREPARED BY: ____________________

4. WEATHER CONDITIONS:_______________

5. CONSTRUCTION SITE AND ACTIVITY:

A. **SITE:** [ ] CALIBRATION LANES [ ] GROUND TRUTH TEST PIT
[ ] BLIND TEST GRID [ ] OPEN FIELD SITE
[ ] ALL SITES

B. **ACTIVITY:** [ ] INTIAL UXO CLEARANCE [ ] GROUND PREPARATION
[ ] SOIL CHARACTERIZATION [ ] SECONDARY UXO CLEARANCE
[ ] POST SURVEY DIG [ ] BASELINE SURVEY
[ ] LANE/GRID LAYOUT [ ] TARGET/CLUTTER EMPLACEMENT
[ ] SITE/FIELD MAINTENANCE

OBSERVATIONS: (Record progress, displays, who is performing work, etc.)

____
____
____
____
____
____

ISSUES AND REMARKS: (Problems, or any observations not covered above.)

____
____

Figure 3-1. Daily construction log.

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FIELD TARGET PLACEMENT SHEET

Location: Aberdeen Proving Ground

Date: 03/25/01

Item Classification: OR (OR - inert Ordnance, CL- Clutter item)

Description: 20 mm Projectile.

ID Number for Munition or Clutter 20MM-ATC-001

Field Test Area B (OF - Open Field, B - Blind Test Grid, CAL - Calibration Lanes)
(Scenarios E - electrical lines, M - moguls, T - Trees, W - wet areas, R - roads)

Additional Description

Grid Location: Grid lane (X-axis number) 14

Grid lane (Y-axis letter) A

Depth from surface	023 m	Clutter Item only:	
Dip	90 deg	Length	______ mm
Azimuth	50 deg	Width	______ mm
Northing (UTM)	677854	Thickness	______ mm
Easting (UTM)	453537	Weight	______ gram
		Type of material	______

Lat (WGS84) ______

Long (WGS84) ______

Target Photographed: (Y or N) ______

Res Mag: ______

Notes: ______

______

______

Placement certification signature: ______

Date of target removal:

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Figure 3-2. Example field target placement sheet.

TARGET PLACEMENT SPREADSHEET
LOCATION: ABERDEEN PROVING GROUND MARYLAND

	Munition Clutter ID No.	Field Test Area	X-axis (number)	Y-axis (letter)	Ground Surface Depth, m	Dip	Azimuth	Northing	Easting	Z Depth Relative to Survey Marker	Target Placement Date	Res Mag	Target Removal Date	Photograph	Field Notes/ Comments
1	20MM-ATC-001	B	14	A	0.23	90	50	553546.787	453539.999		3/25/01			♦	
2	CL-001	OF			1.2	28	68	553556.787	453559.999		3/26/01			♦	
3	CL-002	OF			0.05	0	135	553566.787	453569.999		3/26/01			♦	
4	81MM -ATC-001	CAL	4	B	0.75	-45	0	553576.787	453600.999					♦	
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															

B = Blind Test Grid.
CAL = Calibration Lanes.
OF = Open Field Site.

Figure 3-3. Example target placement format.

SECTION 4. CONSTRUCTION OVERVIEW

4.1 INTRODUCTION

This section contains the step-by-step procedures that need to be followed when constructing each of the four test areas within a standardized UXO site. There are however requirements that are common to all test areas. This construction overview provides the requirements that are common to all sites. Additional information specific to each area is provided following this overview.

4.2 SITE APPROVAL

After an area is selected and the host installation provides verbal approval, a formal site plan is developed and submitted to the installation to construct the standardized UXO site. The site submittal process may vary depending on regulations unique to individual installations. At a minimum, the following documents should be submitted and approved.

a. Any required environmental or NEPA documentation.

b. Any documentation required by the installation (natural cultural, site plans/waivers/ digging permits).

4.3 DEVELOPING AND WRITING WORK AND HEALTH SAFETY PLANS

Most government installations require that a risk assessment be conducted before fieldwork can begin. Appendixes D through N outline the requirements and protocols for conducting the site survey, geological sampling, debris clearance, and target emplacement. These appendixes, along with the test area specific construction requirements, should be used as the statement of work in developing the risk assessment. Typically, a job hazard analysis (JHA), work plan (WP) and health and safety plan (HSP) are included in the risk assessment process. It is the on-site Project Manager's responsibility to comply with all applicable local and OSHA safety requirements.

It is recommended that the scope of the risk assessment cover all tasks associated with establishing the complete standardized UXO test site.

Note: Appendix D outlines the qualifications and work requirements for an UXO crew working in an UXO contaminated area.

4.4 SITE PREPARATION

a. The topographical survey and placement of a survey marker is the first step in site preparation**.** The entire area for the Standardized UXO Technology Demonstration Site is surveyed in 0.3036-meter (1-ft) topography elevations. This survey includes tree lines, telephone lines, utilities, or other features that are within or surround the demonstration area.

Appendix E contains the survey procedures. A survey marker (first order is preferred), having both horizontal and vertical controls, is placed within line-of-site of the test areas. The survey is conducted using North American Datum (NAD) 83 Northing/Easting Universal Transverse Mercator (UTM) format. Specifications for a first order survey marker and UTM format are in Appendix F. Use this survey map to mark the tentative location of all test areas.

b. The entire area that makes up the proposed UXO site will be cleared of all munition and clutter items to a depth of 2 meters. This is a two-phase process that is described in Appendixes D and G. Phase one provides the initial sweep that clears the test site to a depth of 0.6 meter. Phase two checks the performance of the initial clearance and identifies objects that need further investigation and/or removal to a depth of 2 meters.

c. The soil properties of each test area must be understood in order to determine the effect of soil moisture and soil type on UXO detection equipment. Core samples are taken and analyzed as described in Appendix H. Collecting the core samples is accomplished after the initial sweep of the site for UXO and debris has been conducted.

d. A baseline survey to obtain geophysical background characteristics of the entire test site will also have to be conducted (app I). This survey is conducted following the secondary debris/UXO sweep and before the actual construction of any of the test areas. The baseline survey provides the demonstrators common geophysical data to use during the utilization of the Standardized Site. The information collected will be available on the Standardized Site homepage.

4.5 STANDARDIZED AND NONSTANDARDIZED TARGETS

Standardized targets and most of the nonstandardized ordnance will be shipped from ATC to the selected site. Appendix C outlines the procedures and the equipment used to perform the degaussing.

With the approval of the Standardized UXO Technology Demonstration Committee the host installation can provide some nonstandard and site specific ordnance items. A UXO supervisor (either government or contractor) must certify all items provided by the host installation are free of explosive materials (i.e., fuzes, booster charges, propellant, explosive filler, etc.).

4.6 CLUTTER

Obtaining clutter for the standardized test site is the responsibility of the host site unless otherwise requested. The Standardized UXO Committee will provide the size classification and number of clutter items needed. All clutter items provided by the host installation must be certified by a UXO supervisor as free of any explosive materials (i.e., fuzes, booster charges, propellant, explosive filler, etc.). The procedures for cataloging and numbering the clutter items are in Appendix A.

If requested, ATC will provide clutter for the host installations. The clutter will be cataloged according to Appendix A and shipped to the host installation. The shipment will contain copies of all documentation and procedures necessary for field target emplacement.

SECTION 4A. CONSTRUCTION OF THE CALIBRATION LANES TEST SITE

4A.1 INTRODUCTION

Calibration lanes are designed to provide the demonstrator with a sensor library of standardized and calibration targets prior to entering the test field. In addition, the calibration lanes will contain varying size copper wire hoops to understand the resistivity. Four steel spheres will also be buried to help the demonstrator determine the change in response over depth. These items, when induced by magnetic fields, produce a measurable and calculable response that the demonstrator can measure. Another lane has 1-cm thick steel flat plates designed to reflect radar waves. Both of these lanes allow the demonstrator to do quality control checks of their instruments. The rest of the lanes are made up of ordnance items. Except for the mines, each type of the ordnance emplaced in the ground will have the following orientations:

a. N-S (0^o) Middle Expected depth horizontal (0^o).

b. N-S (0^o) Middle Expected depth vertical nose up (90^o).

c. N-S (0^o) Middle Expected depth vertical nose down (-90^o).

d. N-S (0^o) Middle Expected depth 45° nose up (45^o).

e. N-S (0^o) Middle Expected depth 45° nose down (-45^o).

f. E-W (180^o) Middle Expected depth horizontal (0^o).

Mines will be buried near the surface and at their maximum depth.

If an installation has site-specific munitions that are not part of the standardized target, extra lanes may be added in the calibration area to accommodate the installation’s needs. The ground truth data of the site-specific munitions will be kept separate and scored independently.

This section describes how the site is constructed to include site selection, site preparation, establishing the lanes, and eventual site maintenance.

4A.2 PRESITE PREPARATION

4A.2.1 Site Selection

Site selection for the Calibration Lanes should be based on the following criteria:

a. A minimum 2000-square meter area designated for the Calibration Lanes within the site.

b. The soil types and properties of the Calibration Lanes should be representative of soils in an impact area on the installation.

c. Relatively flat and smooth area.

d. Void of trees and scrubs and other natural obstructions.

e. Vegetation that can be maintained.

f. Viable access to the site with a two-wheel drive vehicle.

g. Area exclusively dedicated for the Standardized UXO Technology Demonstration Site program.

h. Area clear of outside electromagnetic interference.

i. Line-of-sight to a survey control point.

j. From both a safety and cost perspective, the sites considered should have a low probability of containing UXO items.

k. Minimal metallic clutter.

4A.2.2 <u>Site Preparation for Calibration Lanes Construction</u>

a. Calibration Layout Design.

(1) Munitions that are generally elongated in shape (aspect ratio not equal to one) are placed into the ground in six orientations and at three different depths.

(2) Munitions generally round in shape (aspect ratio of one) are buried at three different depths.

(3) The first and last opportunity of each Calibration Lane contains a 3.6-kg steel ball buried at 15 cm to provide a uniform signature that can be easily identified when looking at the raw data.

(4) The spacing between munitions under 89 mm in diameter is 2 meters center-to-center.

(5) The spacing between munitions greater then 89 mm in diameter is 3 meters center-to-center.

(6) Between each Calibration Lane for munitions smaller then 89 mm is a 1-meter wide travel lane.

(7) For munitions greater then 89 mm, a 1-meter wide extra travel lane is added to increase the distance between munitions and reduce signature overlap.

(8) One lane has four 5.4-kg steel spheres (shot put) buried between 0.5 to 2 meters in 0.5-meter increments to test the sensor's maximum depth detection capabilities.

(9) Another lane has 12-, 16-, 18- and 20-gauge uncoated copper wire hoops (15- and 30-cm diameter) buried at 0.3 meter.

(10) A third lane has two 1-cm thick by 30- and 61-cm diameter circular steel plates buried at 30 and 91 cm.

b. Appendix J provides the graphical layout for the Calibration Lanes and the list of standard targets with placement depths and orientations.

c. Verification of Field Placement of Lanes. Using the survey map, go to the field and mark the outline of the calibration lane area. Follow local safety procedures if this location contains UXO items. Walk the site and look for variations in the ground such as ditches, holes, depressions or mounds greater than 15 cm (6 in.). If the variation(s) can be easily fixed, finalize the placement of the Calibration Lanes. Soil used to fill any depressions should be taken from an area adjacent to the test site. If the variation(s) are too costly to repair, adjust the location of the Calibration Lanes to take advantage of flat terrain. Lanes should be oriented square to magnetic north.

4A.2.3 <u>Storage Area for Standardized Targets, Hoops, Spheres, and Clutter Items</u>

Standardized targets for the UXO demonstration site will be shipped from ATC to the selected site following approval from AEC. The host installation, following the guidelines in Appendix A, may supply the range related clutter items. The on-site Project Manager is responsible for providing a secured area to store the standardized targets until positioned in the test areas. The munitions will be stored in such a way that no munitions come in contact with each other or the hoops, spheres, and clutter items to ensure that the remnant magnetization values of the items are not compromised.

4A.3 ESTABLISHING THE CALIBRATION LANES

4A.3.1 <u>Field Maintenance Prior to Laying Out the Lanes</u>

Mow the grass/vegetation to a height of 15 cm (6 in.) if applicable.

4A.3.2 <u>Construction Material</u>

The corners of each grid within the Calibration Lanes of a Standardized UXO Technology Demonstration Site are marked using 12.7-mm outer diameter schedule 40 polyvinyl chloride (PVC) hollow piping. The pipe should be cut to a length that, when driven into the soil, provides a sturdy reference point protruding approximately 5 cm out of the ground.

4A.3.3 <u>Lane Layout</u>

Using the site survey map and a geodetic team, identify the corners of the Calibration Lanes and locate the first lane. Place plastic pin flags along the north-south line at 1, 2, and 3 meters and every 6 meters thereafter to 27 meters. Along the east-west line, place pin flags at 1, 2 and 3 meters and every 6 meters thereafter to 42 meters.

Using a 1- by 2-meter metal template (fig. 4A-1), with each corner drilled to insert the 12.7-mm diameter PVC pipe, place one corner over the starting point and insert the first PVC pipes into the ground. Then align the template to magnetic north and drive in the pipes into the remaining corners. Lift and move the template to the next grid area making sure that two corners are always over the previous PVC markers. Repeat this process until the lane is completed.

To construct the adjacent lane, use the markers of the first lane so two holes of the template are over the previous PVC markers, then drive PVC markers into the remaining free holes. Continue this process until you have the required number of lanes shown in the design layout.

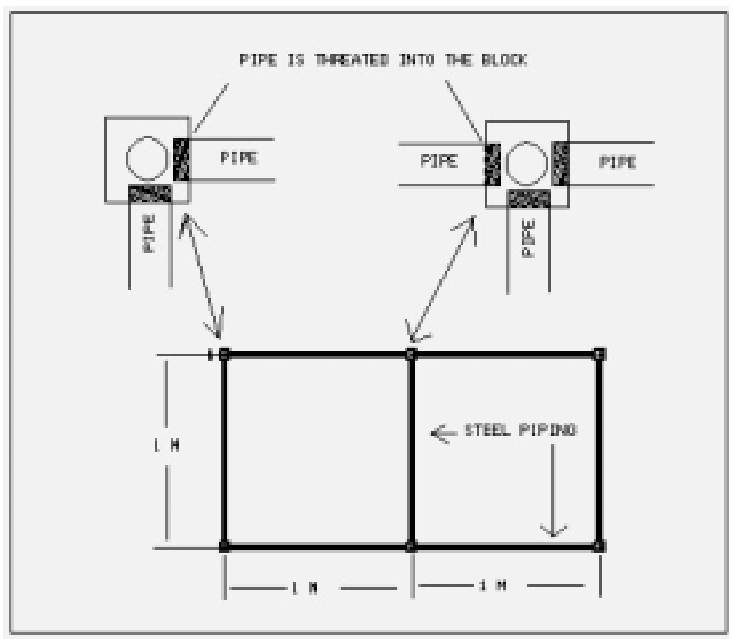

Figure 4A-1. Metal template.

Note: Do not embed the markers completely into the ground. Leave the marker high enough so the template can be used to set up the other lanes. When all the markers have been positioned, drive the pipes further into the ground leaving approximately 5 cm above the surface. End caps will be placed on all markers to identify the four corners of each cell within the Calibration Lanes. Written on each end cap will be the grid location, letter first followed by a number.

4A.3.4 Target Placement

The layout of the Calibration Lanes is shown in Appendix J. Appendix J also provides the list of standard targets and the orientations (i.e., depth, dip, azimuth) at which they need to be emplaced.

The target emplacement methodology is located in Appendix K, Target Emplacement (Auger) work plan.

Note: Clear travel lanes alternate between target emplacements both along and across the grid to allow for straight-line movement from top to bottom and side to side for mobile mounted sensors.

4A.3.5 Site Recovery

Once all the targets have been buried, allow the Calibration Lanes site to rest for at least 3 weeks. Additional soil or seeding may be needed to compensate for settling effects. Fill soil should represent the same soil type and properties of the site.

4A.4 SITE MAINTENANCE

Maintenance includes mowing of the vegetation by hand or with a lawn/garden tractor. Avoid driving the mower wheels over the center of the target lane. Grass height should be maintained between 15 and 17 cm when a demonstrator is testing in the field. The vegetation around the markers should be kept cleared so they can be easily located.

Periodically inspect the grid area for signs of erosion and/or target exposure. For assistance with maintenance problems, contact the ATC UXO Project Manager.

SECTION 4B. CONSTRUCTION OF THE GROUND TRUTH TEST PIT

4B.1 INTRODUCTION

The Ground Truth Test Pit is a 2-meter square by 2-meter deep area cleared of all metallic material. This area allows demonstrators to bury items that are of specific interest. The requirements for presite preparation, site preparation, test pit construction, and site maintenance are essentially the same as the Calibration Lanes and should be performed along with calibration lane work. Specific requirements are listed below.

4B.2 PRESITE PREPARATION

4B.2.1 Site Selection

A 2-meter square area adjacent to the Calibration Lanes is designated for the Ground Truth Test Pit. This test pit should be located close to the Calibration Lanes to ensure that the soil type and geophysical characteristics are the same, but far enough away so that any emplaced items do not interfere with the Calibration Lanes or Blind Test Grid Area.

Note: If the host installation standard policy requires digging permits each time the surface of the ground is broken, it is suggested that the on-site Project Manager work with the installation/base to designate this area as a permanent dig zone.

4B.2.2 Outline of Steps in Site Preparation in Test Pit

a. Design Layout. The design of the Ground Truth Test Pit is a square 2 by 2 meters. White pin flags with nonmetallic posts mark the Ground Truth Test Pit on each corner and along the outside edge between the corners.

b. Field Site Placement Verification. Using the survey map go to the field and locate the visible corner markers that outline the boundary of the test pit. Walk the site and identify anything that might cause soil erosion or collect water. If the problems can be fixed relatively easy, such as constructing an earthen berm, finalize the placement of the test pit. If the problem cannot be easily fixed, move the test pit to avoid the problem area.

4B.2.3 Storage Area for Demonstrator Supplied Targets

Any items supplied by a technology demonstrator for placement in the test pit must be certified as inert. The demonstrator is responsible for the degaussing, inert certification, or other pre-emplacement requirements for any demonstrator specific item that they would like to utilize. Short-term storage of these items will be in a secure area. The munitions will be stored in such a way that no munitions come in contact with each other or other items in storage. The on-site Project Manager is responsible for maintaining munitions inventory integrity.

4B.3 TEST PIT CONSTRUCTION

4B.3.1 Field Maintenance Prior to Laying Out the Test Pit

If vegetation exists, and it is safe to do so, cut it to the lowest possible level prior to the work crew coming on site.

4B.3.2 Construction Material

White pin flags with nonmetallic posts are used as temporary markers during the excavation of the test pit. After construction the site is marked using 12.7-mm outer diameter schedule 40 PVC pipe cut to a length that, when driven into the soil, provides a sturdy reference point protruding 5 cm out of the ground. Eight pieces are required, one for each corner and one in the center of each side.

4B.3.3 Equipment List

a. Bucket Loader.

b. Tarp.

c. Hand Shovel.

4B.3.4 Constructing the Ground Truth Test Pit

Conduct an initial debris sweep of the area. The goal is to remove and identify all electrically conductive or foreign items within the Ground Truth Test Pit site to a depth of 2 meters in 0.6-meter increments. The site should be cleared of any metallic debris and clutter. This should be done in accordance with the procedures found in Appendixes D and G. The site debris clearance procedures are as follows:

a. Mark the center and mark the along each side of the 4-square meter Ground Truth Test Pit using white pin flags with nonmetallic posts. Maintain a record of anomalies excavated and the progress of the debris clearance action.

b. With a passive ferrous metals magnetometer instrument, where sensitivity is set on the highest sensitivity range practicable, sweep the area in an east-west direction and excavate any anomaly detected. Return to the starting point, with an electromagnetic (active all-metal) inductive detector, sweep the area in a north and south direction and excavate any anomaly when detected. When the previous sweeps indicate a large number of anomalies, go over the site again using an electromagnetic (active all-metal) inductive detector in an east-west direction and excavate any anomaly detected. Follow up with a quality control (QC) check of the area using the electromagnetic detector and excavate any anomaly when detected. Appendix D, UXO Work Plan, outlines which instruments can be used and the operational restrictions when working in an UXO contaminated area.

c. Dig and remove any anomaly (hit) detected with a depth of 0.6 meters or less. Debris items found within the Ground Truth Test Pit can be saved and used as clutter items in the Blind Test Grid or Open Field Site after they are processed as described in Appendix A. If debris items are collected from an UXO contaminated site, a qualified UXO technician must certify them to be free of explosive materials.

d. Record all debris items found at the pit site and the total number of anomalies excavated at the site on a daily basis using the daily construction log sheets.

e. After all debris has been cleared, remove the first 0.6 meter of soil with a bucket loader (armored if necessary) and place it on the tarp. Save all soil from the Ground Truth Test Pit to use as backfill for the pit.

f. Conduct another sweep of the pit and remove all anomalies detected with a depth of 0.6 meter or less.

g. Repeat step b through f until a depth of 2 meters is obtained.

h. Before any soil is backfilled in the Ground Truth Test Pit, conduct a final sweep of the walls and floor, the pile itself, and remove any anomalies detected.

i. Backfill the Ground Truth Test Pit with the soil taken from the pit.

j. Establish native vegetation on the Ground Truth Test Pit.

4B.3.5 Site Recovery

No site recovery is required.

4B.4 SITE MAINTENANCE

a. Inspect/Maintain Site. Conduct periodic inspections (depending on local weather conditions and the growing season).

b. Vegetation Growth Control. Mow with hand or lawn/garden tractor to 15 to 17 cm; weed whack around markers.

c. Signs of Erosion. Document and notify/discuss erosion problems with the ATC Project Manager before taking corrective measures.

SECTION 4C. CONSTRUCTION OF THE BLIND TEST GRID AREA

4C.1 INTRODUCTION

The Blind Test Grid is designed to test a demonstrator's ability to detect and discriminate clutter from ordnance under controlled conditions. The Blind Test Grid will be smoothed to reduce background noise from uneven terrain. The demonstrator will reference an emplaced grid system which eliminates navigational errors by allowing demonstrators to know their location on the field at all times. At the center of each cell within the grid there are three target possibilities - nothing, clutter, or ordnance. All of these conditions remove the influence of the platform from the response, allowing sensor evaluation.

4C.2 SITE PREPARATION

4C.2.1 Site Selection

The site selected for the Blind Test Grid should be based on following criteria outlined by the Standardized UXO Technology Demonstration Site Committee:

a. A minimum of 4000 square meters.

b. Locate the Blind Test Grid such that it can be expanded for future use.

c. The soil types and properties of the Blind Test Grid should represent soils in an impact area on the installation as well as the Calibration Lanes.

d. Relatively flat and smooth area with little ground disturbance.

e. Devoid of trees and scrub.

f. Vegetation that can be maintained.

g. Viable access to the site with a two-wheel drive vehicle.

h. Located in an area dedicated for the Standardized UXO Technology Demonstration Site Program only.

i. Limited electromagnetic interference.

j. Line-of-sight to a survey control point.

k. Minimal metallic clutter.

4C.2.2 Site Preparation for Blind Test Grid Construction

a. Verification of Field Placement of Lanes. Using the survey map, go to the field and outline the grid area. A visible marker is placed at each corner of the Blind Test Grid as an aid in identifying the boundary for the field. The shape of the Blind Test Grid is rectangular. Walk the site and look for variations in the ground such as ditches, holes and depressions or mounds greater then 15 cm. If the problems can be easily fixed, finalize the placement of the Blind Test Grid. If correcting the problem(s) is too costly, adjust the location of the Blind Test Grid. Soil used to fill any depressions should be taken from an area adjacent to the test site.

b. Design Layout. The Blind Test Grid has clear travel lanes, running both north and south and east and west, alternating between the target emplacement lanes. This allows for the movement of mobile mounted sensor equipment in a straight line, top to bottom and side to side across the grid area. The first and last target opportunity in each Blind Test Grid lane is a 3.6-kg steel ball buried 15 cm deep. This provides a uniform signature that can be easily identified when looking at the target signatures. A schematic of the layout is in Appendix L.

4C.2.3 Storage Area for Standardized Munitions Targets and Clutter

Standardized targets for the UXO demonstration site will be shipped from ATC to the selected site following approval from AEC. The host installation, following the guidelines in Appendix A, may supply the range related clutter items. The on-site Project Manager is responsible for providing a secured area to store the standardized targets until they are buried in the test areas. The munitions will be stored in such a way that no munitions come in contact with each other or the hoops, spheres, and clutter items.

4C.3 SITE CORRECTION

Correct any problems noted from the field site placement verification visit - smooth out areas containing depressions or elevations of 15 cm or greater. Fill holes or depression with soil that matches the soil type from the area and pack it down. Filled-in holes may need to be dressed after the soil settles. If soil erosion is of concern, plant grass seed and cover with straw to stabilize the area. If problems persist, notify the ATC Project Manager for directions on the approach to mitigate the problem. The site should be cleared of any metallic debris and clutter. This should be done in accordance with the procedures found in Appendixes D and G.

4C.4 BLIND TEST GRID CONSTRUCTION

4C.4.1 Field Maintenance Prior to Laying Out the Lanes

If vegetation exists mow the grass to a height of approximately 15 cm.

4C.4.2 Construction Material

The corners of each cell within the Blind Test Grid area are marked using a 12.7-mm outer diameter, schedule 40 PVC piping cut to a length that, when driven into the soil, provides a

sturdy reference point protruding 5 cm out of the ground. A mallet is necessary to drive the PVC piping into the ground. The Blind Test Grid requires 2400 18-cm PVC sections to mark all the cells.

4C.4.3 Lane Layout

For alignment, use the site survey map and/or survey crew/instrument. Identify the corners of the Blind Test Grid area and the location of the first lane. Place plastic or nonmetallic pin flags along the north-south line at 1, 2, and 3 meters and every 6 meters thereafter to 27 meters. Along the east-west line, place pin flags at 1, 2, and 3 meters and every 6 meters thereafter to 42 meters.

Using a 1- by 2-meter metal template (fig. 4C-1), with each corner drilled to insert the 12.7-mm diameter PVC pipe, place one corner over the starting point and insert the first PVC pipes into the ground. Lift and move the template to the next grid area making sure that two corners are always over the previous PVC markers. Repeat this process until the first lane of the Blind Test Grid is completed. To construct the adjacent lane, use the markers of the first lane so two holes of the template are over the previous PVC markers. Drive PVC markers in the remaining holes of the template. Continue the process until you have the desired number of lanes shown in the site's design layout.

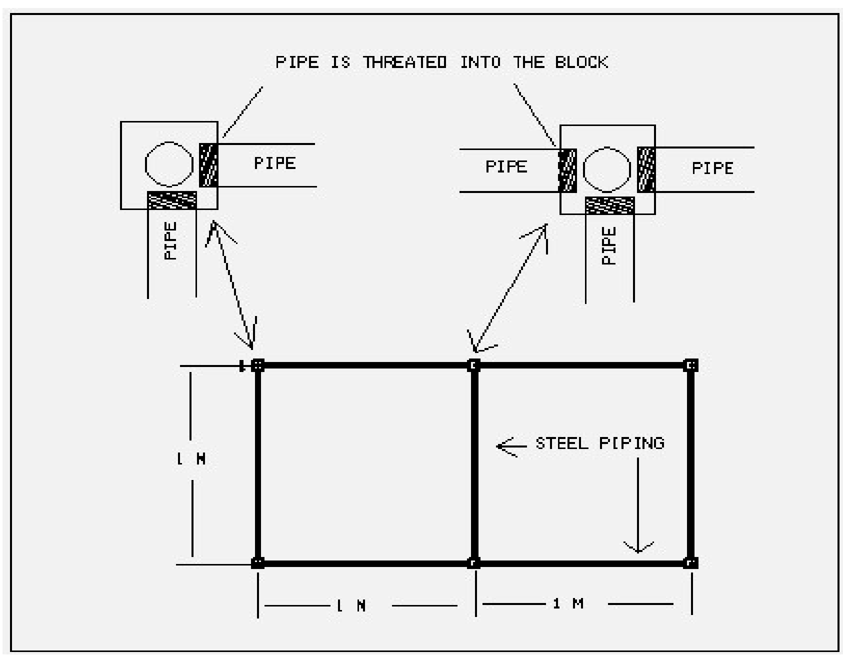

Figure 4C-1. Metal template.

Note: Do not embed the markers completely into the ground. Leave the marker high enough so the template can be used to help set up the other lanes. When all the markers have been placed in the ground, drive the markers further into the ground leaving 5 cm above the surface.

4C.4.4 Target Placement

The Blind Test Grid design layout (on file with the Standardized UXO Technology Demonstration Site Ground Truth Committee - not available to the demonstrator) details the depth, the dip, and the azimuth of the munitions and clutter being buried in each lane. All targets are placed in the center of the 1-meter grid. The target emplacement methodology is located in Appendix K.

Note: Clear travel lanes are alternated between target emplacements running both north and south and east and west to allow straight-line movement from top to bottom and side to side for mobile mounted sensors. An example is shown in Appendix L.

4C.4.5 Site Recovery

Once all the targets have been buried allow the site to rest for at least 3 weeks. Additional soil or seeding may be needed to compensate for settling effects. Fill soil should represent the same soil type and properties of the site.

4C.5 SITE MAINTENANCE

Maintenance includes mowing of the vegetation by hand or with a lawn/garden tractor. Avoid driving the mower wheels over the center of the target lane. Grass height should be maintained between 15 and 17 cm when a demonstrator is testing in the field. The vegetation around the markers should be kept cleared so they can be easily located.

Periodically inspect the grid lanes for signs of erosion and/or target exposure. For assistance with maintenance problems, contact the ATC UXO Project Manager.

SECTION 4D. CONSTRUCTION OF THE OPEN FIELD SITE

4D.1 INTRODUCTION

The Open Field Site is designed to test the demonstrator detection equipment under realistic field conditions. These field conditions could consists of woods, varying terrains, moguls, power lines, roads, boulders, and wet areas that challenge the demonstrator's ability to detect ordnance.

4D.2 PRESITE PREPARATION

4D.2.1 Site Selection

The area selected for the Open Field Site should be based on following criteria outlined by the Standardized UXO Technology Demonstration Site Committee:

a. A minimum 4-hectare area.

Note: Smaller areas of an installation that have different soil types, vegetation, or topographical characteristics (not part of the Open Field Site) may be used to represent unique scenarios. A minimum of a 1-hectare area should be designated.

b. The soil types and properties of the open field should represent soils in an impact area on the installation as well as the Calibration Lanes.

c. Varying terrain conditions - smooth, rough, hilly, and flat terrain.

d. Contain a variety of native vegetation - trees, forest, grass, woodland brush, desert brush, cacti, etc.

e. Viable access to the site with a two-wheel drive vehicle.

f. Area exclusively dedicated for the Standardized UXO Technology Demonstration Site program.

g. Limited electromagnetic interference.

h. Line-of-sight to a survey control point.

i. Minimal metallic clutter.

4D.2.2 Site Preparation for Open Construction

Design layout in the open field will vary between sites according to the unique features associated with each site. The size, shape, soil matrix, vegetation, obstacles, and field terrain the site determine the location and types of challenges and scenarios. A scenario is a minimum of

1-hectare area that tests the demonstrator on a specific statistically significant area. An example of a man-made scenario is the mogul design built at the Aberdeen Proving Ground (APG) Standardized Site and described in Appendix M. In designing the layout, the following questions need to be considered. Appendix N provides the methodology for the placement of targets.

a. Is the shape of the field conducive for construction of a unique scenario?

b. Is there an area where the conditions are dramatically different? Is it a large enough area to make a scenario?

c. What vegetation exists out in the field? Can the vegetation be used to develop a challenge?

d. What obstacles in the field may inhibit demonstrators from covering the field (boulders, telephone poles, fallen trees and woods)?

e. Is there any natural or man-made landscape in the field that may inhibit the demonstrators' ability to cover the field (hills, washout areas, roads and rough terrain)?

4D.2.3 Storage Area for Standardized Munitions Targets and Clutter

Standardized targets for the UXO demonstration site will be shipped from ATC to the selected site following approval from AEC. The host installation, following the guidelines in Appendix A, may supply the range-related clutter items. The on-site Project Manager is responsible for providing a secured area to store the standardized targets until they are positioned in the test areas.

4D.3 SITE PREPARATION

4D.3.1 Ground Preparation

Ground preparation will vary depending on the field conditions and scenarios that are developed. Depending on the challenge or scenario the ground preparation could consist of cutting grass, building moguls, clearing trees/brush, or planting grass. Stabilize any area in the open field where soil erosion is occurring. If soil erosion problems persist, notify the ATC Project Manager for directions on the approach to mitigate the problem. The site should be cleared of any metallic debris and clutter. This should be done in accordance with the procedures found in Appendixes D and G.

4D.3.2 Target Layout

The target layout and target emplacement are the responsibility of ERDC with ATC providing technical support on guidelines for target locations. The developments of the challenge/scenario areas are approved by AEC and ATC. The Standardized UXO Ground Truth Committee determines the actual numbers of items to place in the field. Due to the competition sensitive nature of this information, it is not be part of this document.

4D.4 OPEN FIELD CONSTRUCTION

4D.4.1 Field Maintenance Prior To Emplacing Targets

Depending on the challenges/scenarios, it may be possible to cut or clear vegetation prior to emplacing targets. The on-site Project Manager, along with ERDC and ATC, will make the determination.

4D.4.2 Target Placement

Target emplacement is a significant issue in the open field construction. The orientation, depth, and overlapping items strongly influence the signature seen by the sensor. The calibration lane is used to train sensor systems and allow them to utilize their algorithms to correlate expected signatures to signals from the open field.

The open field design layout (on file with the Standardized UXO Technology Demonstration Site Ground Truth Committee - not available to the demonstrator) details the depth, the dip, and the azimuth of the munitions and clutter being buried in the field. The design layout is determined by ERDC and ATC with AEC approval.

The target emplacement methodology is located in Appendixes K and N.

4D.4.3 Site Recovery

Once all the targets have been buried, allow the open field area to rest for at least 3 weeks. Additional soil or seeding may be needed to compensate for settling effects. Fill soil should represent the same soil type and properties of the site.

4D.5 SITE MAINTENANCE

The on-site Project Manager should be present during all site maintenance activities to ensure proper care is taken of the site.

Maintenance includes mowing of the vegetation by hand or with a lawn/garden tractor. Depending on the particular challenge, some of the grasses will be allowed to grow while other areas will be kept short. For assistance with maintenance problems, contact the ATC UXO Project Manager.

SECTION 5. WEATHER AND SOIL MOISTURE DATA ACQUISITION SYSTEMS

5.1 INTRODUCTION

The installation of a weather data acquisition (DAS) system should be considered early in the site-planning phase. This system needs to be located in an open area free of trees or other obstructions that may interfere with the collection of meteorological data. A Time Domain Reflectometry (TDR) soil moisture meter will be attached to the weather station to record continuous moisture measurements. The system may need to be protected from pilferage if not located in a secured area.

5.2 STANDARD METEROLOGICAL STATION CONFIGURATION

5.2.1 Basic Hardware

The standard meteorological station hardware consists of:

a. A grounded freestanding tripod supporting a main mast that allows sensors to be mounted to a height of 3 meters.

b. Sensor mounting hardware such as the wind monitor cross-arm, gill radiation shield, solar radiation arm, and others attached to the mast.

c. A fiberglass enclosure, attached to the main mast, that houses the interfaces, instrumentation, and power supply.

d. A data logger; programmable and capable of accepting and supporting a variety of sensors. Used to program user specified sampling and output intervals (as high as one per second, minimum) and as a controller for particular sensors. The versatility of the data logger allows the user to specify data output configurations with measurement averages, maximums and minimums, totals, and cumulative values being options.

e. The station is independently powered and utilizes solar assistance to maintain its power supply.

5.2.2 Standard Sensor Package

The standard sensor configuration includes air temperature, relative humidity, barometric pressure, solar radiation, soil temperature, precipitation, and wind speed and direction. Multiple sensors of the same type can be installed for redundancy or to monitor different levels of interest such as wind speed or soil temperature at different depths. Other parameters of particular interest such as soil moisture, evaporation, etc., are accommodated as required. Sampling rate and output frequency are user defined as required. Typical specifications for the standard sensors are described below.

5.2.3 Recommended Equipment - Required Ranges

a. Air Temperature. This parameter is measured using a Vaisala model No. HMP45C temperature and relative humidity probe or equivalent probe. Accuracy for the temperature probe is $\pm$0.2 $^{\circ}$C from -40 to 60 $^{\circ}$C. Installation height is 2 meters.

b. Relative Humidity. This parameter is monitored using a Vaisala model No. HMP45C or equivalent probe. Accuracy for this sensor is $\pm$2 percent relative humidity (0 to 90 percent relative humidity) and $\pm$3 percent relative humidity (90 to 100 percent relative humidity). Installation height is 2 meters.

c. Barometric Pressure. This parameter is measured using a Vaisala pressure transmitter, model No. PTB101B. Total accuracy is $\pm$6 mBars at -40 to 60 $^{\circ}$C. Installation height is approximately 1.75 meters.

d. Solar Radiation. Solar radiation is monitored using a LiCor, model No. LI200X, pyranometer with a silicon photovoltaic detector. Light spectrum waveband is 400 to 1100 nm with a typical accuracy of $\pm$3 percent. Installed height is 2.5 meters. Units are watts per square meter (W/m^2).

e. Soil Temperature. Soil temperature is monitored using the Campbell Scientific model No. 107B temperature probe which is encapsulated and is suitable for burial. The epoxy thermistor bead has a measurement range of -35 to 50 $^{\circ}$C and a typical accuracy of $<\pm$0.2 $^{\circ}$C.

f. Wind Speed. Wind speed is monitored using the R. M. Young wind speed/direction sensor package, model No. 05103-5. The wind speed accuracy is $\pm$0.3 m/s and has a range of 0 to 100 m/s. Threshold sensitivity is 1.0 m/s. Installed height is approximately 3 meters. Data output is mean horizontal wind speed and units are meters per second.

g. Wind Direction. Wind direction is monitored using the R. M. Young wind speed/direction sensor package, model No. 05103-5, accuracy of $\pm 5^{\circ}$. Installed height is approximately 3.0 meters. Data output is unit vector mean wind direction and units are in degrees from North.

h. Precipitation. Precipitation is monitored by a Texas Electronics sensor, model No. TE525MM, with tipping bucket mechanism calibrated for millimeter output. Readings are cumulative for the specified collection period. Accuracy for rainfall rates is as follows:

(1) Up to 10 mm/hr, $\pm$1 percent.

(2) 10 to 20 mm/hr, +0, -3 percent.

(3) 20 to 30 mm/hr, +0, -5 percent.

5.2.4 Hardware Inventory

An inventory of a spare sensor for each parameter is recommended. For deployment of more than 1 year, a sensor exchange may be necessary to maintain calibration specifications.

5.2.5 Data Retrieval

Recorded data are stored in an internal buffer in the data logger and can be retrieved during site visits by downloading the data into a storage module. A module could be left attached to the data logger and periodically exchanged with another module and taken back to the office for download or, with a laptop, downloaded on site. Another option for data retrieval is via phone modem using either a dedicated telephone line or cell phone.

5.3 TIME DOMAIN REFLECTOMETRY (TDR) MOISTURE METERS

5.3.1 Number of TDR

At least three TDR moisture meters will be placed throughout the field. One TDR probe will be placed near the weather station so the weather station's data logging system can be connected to the probe and take continuous moisture level measurements remotely. The other probes will be placed in strategic areas where the soil moisture conditions vary due to topography (wet areas) or vegetation differences (woods).

5.3.2 Specifications

5.3.2.1 Weather station moisture probes.

a. Compatible. The soil moisture probe used to take continuous moisture levels must be compatible with the data logger used in the weather station.

b. Moisture Readings. A minimum of four soil moisture depths will be recorded per reading. The depth ranges for each soil moisture measurement are 0 to 15 cm, 15 to 30 cm, 30 to 60 cm, and 60 to 90 cm.

c. Temperature Readings. The soil moisture probe will be capable of measuring soil temperatures that correspond to the soil moisture depths.

5.3.2.2 Field moisture probes.

a. Hardware. A handheld digital meter with a quick connect system to read the outputs of soil moisture probes in the ground is required. The digital meter can be configured to read instant soil moisture or be connected to the data logger.

b. Moisture Readings. A minimum of four soil moisture depths will be recorded per reading. The depth ranges for each soil moisture measurement are 0 to 15 cm, 15 to 30 cm, 30 to 60 cm, and 60 to 90 cm.

c. Installation. The installation of field moisture probes shall not take longer than 15 minutes.

5.4 DATA ACQUISITION

a. Hourly - air temperature, relative humidity, barometric pressure, solar radiation, soil moisture, soil temperature, wind direction, wind speed, and precipitation.

b. 0800 and 1600 - field moisture meter readings.

5.5 DATA DISSEMINATION

The on-site Project Manager will store the data and make it available to the demonstrator by request through AEC or as specified in an applicable contract with ATC.

SECTION 6. SCHEDULING PROTOCOLS

6.1 GENERAL

This section outlines the steps and process necessary to allow demonstrators access to the site.

6.2 INITIAL REQUEST

The demonstrator submits a Standardized UXO Technology Demonstration Site request form to the ATC Project Manager at least 45 days in advance of the date being requested. The request form can be obtained through the AEC website (http://aec.army.mil/). Below are the initial general requirements in submitting the request form.

- Demonstrator's name, address and telephone number.
- Site location - APG and YPG.
- Area to be tested.
- Dates requested.
- System Description - The description should include type of instrument, (physics, characteristics, dimensions), specifications of transmit pulses, bandwidths, instrument settings (gains, etc.), description of preprocessing (averaging, background subtraction, etc.), measurement units, lane spacing, instrument height, orientation, equipment safety hazards and physical characteristics.
- General Collection Procedure - Process, e.g., handheld, vehicular, etc., by which data are collected in detail - i.e., spatial sampling rate, frequency and/or time sampling rate, file format (ASCII, binary), data format, etc.
- Upon receipt of initial request package, ATC and AEC will review the package. Once the request is approved, the ATC Project Manager will coordinate with the demonstrator and on-site Project Manager to arrange a date for conducting the test.

6.3 THIRTY DAYS IN ADVANCE/SITE USAGE REQUIREMENTS

Thirty days prior to the test date, the demonstrator is responsible for supplying the following information to ATC and the on-site Project Manager for review and comment:

a. Test Plan. The demonstrator's description of detection/sensor equipment, summary of how data are collected, analyzed, and the decision process by which algorithms discriminate between ordnance and munitions. Specific requirements for prioritizing by signal strength and discrimination should be addressed. The test plan should describe objectives and planned use of

Calibration Lanes/Ground Truth Test Pit, Blind Test Grid, and Open Field Site. The Calibration Lanes must be completed first, followed by the Blind Test Grid, and last the Open Field Site, in order. No partial scoring of any of the areas is permitted.

b. Quality Assurance (QA) Plan. A description of the QA procedures to be employed during survey including lane spacing, sampling rates, and estimated accuracy of navigation and tracking systems.

c. Quality Control (QC) Plan. A description of how systems checks are conducted to maintain tracking accuracy, etc.

d. Site Personnel List. Provides the names of individuals the demonstrator plans to bring on-site. The demonstrator may be require to also provide individual social security and drivers license numbers for access to a military installation. Foreign nationals may need to submit a site visit request through their embassy. The local security office should be contacted for guidance and process time requirements.

e. Support Equipment List. A list of all demonstrators' equipment being used to conduct the test. This information is used to determine storage facility and other on-site requirements.

f. Electromagnetic/Frequency Modulation (EM/FM). Provides a listing of frequency and power from EM/FM and radio (including Differential Global Positioning System (DGPS)) equipment. This information is necessary to determine any radio frequency (RF) interference at the host installation.

g. Funding. The Standardized UXO Technology Demonstration Site charges a flat daily fee to cover field support and independent oversight functions. A separate charge is also made for each performance scoring evaluation. This standard charge may vary depending on the number or combination of site scenarios scored.

6.4 FIELD COORDINATION

After the demonstrator receives approval to utilize the site, the demonstrator and on-site Project Manager will finalize scheduling, security, and logistics issues. Changes or issues arising in scheduling by the demonstrator need to be coordinated with ATC Project Manager and on-site Project Manager.

SECTION 7. FIELD TESTING OPERATIONS AND OVERSITE PROTOCOLS

7.1 INTRODUCTION

This section outlines the responsibilities of the Standardized UXO Technology Demonstration Site, on-site Project Manager.

7.2 ON-SITE PROJECT MANAGER RESPONSIBILITIES

7.2.1 Providing Site Information to Demonstrators

a. Site layout map, topography, and location of the test grids and survey monuments.

b. Soil type, sieve analysis, and moisture content (past data) available on AEC website.

c. Average rainfall, average temperature, and average humidity.

d. Job Hazard Analysis and Operations Work Plan.

7.2.2 Coordinating and Scheduling of Facility

Scheduling and coordination of the demonstrator's use of the Standardized UXO Technology Demonstration Site is through the ATC Project Manager. Local coordination of materials, personnel, and any other resources is the responsibility of the on-site Project Manager.

7.2.3 Infrastructure provided for Demonstrator

a. Secure temporary storage space for demonstrator equipment during the test. Suggested size is 6 by 12 by 4 meters with a 2-meter (minimum) wide access door.

b. Demonstrator work area to include an area to process data, phones, desk, bathrooms and battery charging. The area should be within a reasonable distance of the test site. Another option is to provide a work trailer at the site.

c. Shovels, hand-augers for placement and removal of targets in the Ground Truth Test Pit.

7.2.4 Site Maintenance

Maintaining the Calibration Lanes, Ground Truth Test Pit, Blind Test Grid, and Open Field Site involves:

a. Controlling vegetation/weed growth.

b. Repairing grid markers/boundary markers.

c. Erosion control, if necessary - coordinate with the ATC Project Manager.

d. Maintenance unique to challenge areas.

7.2.5 Security

a. Ensure that security clearances are on file for contractor personnel.

b. Arrange escorts for personnel without clearances.

7.2.6 Briefing the Demonstrator

a. Installation/site rules and regulations.

b. Security.

c. Range control procedures.

d. UXO safety.

e. Site safety and health (daily).

7.2.7 Daily Log

Maintain a sign-in/sign-out daily log of all field personnel.

7.2.8 Oversight

a. Ensuring the demonstrator is operating according to the test safety and health plan and the quality assurance plan for conducting the test.

b. Collecting raw data from the demonstrator before clearing the demonstrator from leaving the site.

7.2.9 Test Information Record

Test operations will be documented by the site managers on Standardized Forms provided by the program. Information to be collected will include:

a. Observations relating to the demonstrator's on-site operations.

b. Equipment (detector/sensor/platform) reliability.

c. Number of people (including job title and duties) and time required for setup operations, performing the test and making repairs.

d. Daily activities including time at each test area/grid/scenario, etc.

7.2.10 Weather and Soil Acquisition Record

Maintaining daily record of ground moisture and weather conditions during demonstrator's test.

a. Weather. Complete weather data from the standard meteorological station configuration are recorded on the hour, each hour, while the demonstrator is on site. The configuration includes air temperature, relative humidity, barometric pressure, solar radiation, soil temperature, precipitation and wind speed and direction (section 5).

b. Soil moisture readings at remote sites are obtained and recorded at 0800 and 1600 hours local time when a demonstrator is on the field.

c. Collected weather and soil data are made available to the demonstrator on request via ATC Vision Program.

7.2.11 Ground Truth Test Pit/Calibration Targets

Providing standardized targets/clutter items/spheres/hoops, (including data, i.e., size, weight, length, and material type) to the demonstrator for calibration of sensors/detectors at the Ground Truth Test Pit.

7.2.12 Health and Safety Requirements

The host installation Job Hazard Analysis and Operations Work and Health and Safety Plan will be read and signed by each demonstrator. Each demonstrator is also responsible for compliance with all host installation safety and security requirements noted during the on-site Project Manager’s briefing.

SECTION 8. TESTING PROCEDURES

8.1 INTRODUCTION

This section is designed to outline test procedures and data submittal requirements during a test. At all times, a government representative will be on the field during a demonstrator's test.

8.2 FIELD SCHEDULE

8.2.1 First Day

a. A final review of the demonstrator's submitted test plan to guarantee that both the government representative and demonstrator understand the scope, schedule and time frame.

b. Conduct a site walk through and provide the demonstrators their base of operations and staging area.

c. Briefings on site procedures (range control), UXO safety (as appropriate), Job Hazard Analysis, Operations Work Plan, and test protocols. At this time all participants will affirm the understanding of safety precautions.

d. Demonstrator sets up equipment and begins field-testing, if time permits.

8.2.2 Daily Field Operations

a. Conduct daily site safety briefing, review check list and planned field operations.

b. Demonstrator conducts systems checks/calibrations.

c. Demonstrator begins field testing work in the following sequence:

(1) Calibration Lanes and, if desired, the Ground Truth Test Pit.

(a) Unlimited time (no recording of time).

(b) Unlimited trial runs (no recording of trial runs).

(2) Blind Test Grid (Calibration Lanes must be completed first).

(a) Test time recorded and account for any down time.

(b) Runs - record number of times and directions the sensors went over the grids.

(3) Open Field Site (Calibration Lanes and Blind Test Grid must be completed first).

(a) Test time recorded and account for any down time.

(b) Runs - record number of times and directions the sensors went over the open field.

8.3 FIELD DATA SUBMISSION

Demonstrator must submit raw sensor data for each area covered to the on-site Project Manager before leaving the site. The raw sensor data shall be provided on digital storage media (i.e., CD, floppy disk, JAZ, Zip, etc.). To the extent practical, the raw data should be in ASCII format. If this format is not practical for the demonstrator, any format desired by the demonstrator will be accepted, if sufficient detail is provided to allow proper reading of the file. Storage of all data will be in the ATC digital library.

Raw sensor data are sensor specific, rudimentary forms of data with the corrected Global Positioning System (GPS) will be applied by the sensor system prior to being subjected to post processing algorithms. (For example, raw data for a magnetometry sensor might be the magnetic flux readings in nano-Tesla relative to time and position, rather than a graphically formed image of these readings.)

8.4 POST-TEST OPERATIONS

8.4.1 Field Activities

Discuss field activities and any issues that came up during testing.

8.4.2 Demobilization

Demobilization of equipment by the demonstrator.

8.4.3 Site Clean-up

Site clean up (good housekeeping, i.e., bag and dispose of trash properly) is the responsibility of demonstrator. All equipment and materials brought to the site by the demonstrator will be removed before the demonstrator is allowed to clear the site.

8.4.4 Exit Survey Form

An exit survey form (fig. 8-1) will be provided to the demonstrator. The demonstrator must complete and mail the form to AEC prior to the release of performance scores.

8.4.5 Demonstrator's Scoring Performance Information

A status report (fig. 8-2) of the demonstrator's scoring performance information at the specific Standardized UXO Technology Demonstration Site will be made available over the Internet through the AEC website (http://aec.army.mil/).

EXIT SURVEY FORM

1. CONTRACTOR/DEMONSTRATORS NAME_____________________

2. STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE AND DATE:

   APG_______ YPG_________

3. SERVICES PROVIDED: Excellent__ Satisfactory___ Unsatisfactory _____
   Comments________________________________
   ____
   ____

4. TEST PROCEDURES: Adequate: Yes__No__ Suggestions______________
   ____
   ____

5. FIELD CONDITIONS: Adequate: Yes_No_ Suggestions_______________

6. EQUIPMENT TESTED___________________________

7. OPERATIONAL PROBLEMS ENCOUNTERED (List)

   A. GROUND TRUTH TEST PIT_____________________________
   ____
   ____

   B. CALIBRATION LANES________________________
   ____
   ____

   C. BLIND TEST GRID____________________________
   ____
   ____

   D. OPEN FIELD SITE ____________________________
   ____
   ____

7. OVERALL RATING: Excellent__ Very Good__ Good__ Poor___ Very Poor___

8. REASON FOR RATING COMMENTS____________________
   ____
   ____

9. Mail to: U.S. Army Environmental Center
   ATTN: SFIM-AEC-PCAT (George Robitaille)
   Aberdeen Proving Ground, MD 21010-5401

Figure 8-1. Exit survey form.

DEMONSTRATOR'S STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE SCORING PERFORMANCE STATUS REPORT

Date of Status Report______________________________

1. Demonstrators name______________________________

2. Type of equipment used_____________________________________
____

3. Test Site Location [ ] APG [ ] YPG - Date (s) utilized/completed and date(s)

    a. Calibration Lanes__________________________

    b. Blind Test Grid____________________________

    c. Open Field Site____________________________

    d. Other_____________________________________

4. Status of Demonstrators Scoring Report <u>(if demonstrator completed Blind Test Grid or Open Field or both) Note: a, b, and c below</u>

    a. If process data has not arrived: Enter - "PENDING - WAITING FOR PROCESSED DATA FROM DEMONSTRATOR"

    b. If processed data arrived: Enter - "PENDING - PROCESSED DATA IS CURRENTLY UNDER REVIEW BY THE SCORING COMMITTEE"

    c. If the scoring report is completed: Enter - "COMPLETED - REPORT NUMBER AND DATE"

5. Remarks____
____
____
____

Figure 8-2. Status report.

8.5 PROCESSED DATA SUBMITTAL

Demonstrators must submit processed data within 30 days after test completion. The user must provide to the on-site Project Manager, sensor response output and algorithm results declarations in a government provided, electronic, Excel® spreadsheet. An example of the format for a hypothetical Blind Test Grid that yielded seven sensor responses is shown in Table 8-1.

TABLE 8-1. SAMPLE ALGORITHM RESULTS DECLARATION TABLE FOR BLIND TEST GRID

	Letter	Number	Response Stage	Discrimination Stage/Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	A	1	0.849	0	C	20-mm			
2	A	2	2.852	29	O	20-mm	1.72	142	-69.40
3	A	3	8.209	86	O	105-mm P	0.86	16	-52.10
4	A	4	1.757	20	C	105-mm P			
5	B	1			B				
6	B	2	9.980	101	O	105 H	0.37	140	40.16
7	B	3	12.679	130	O	105-mm P	0.28	137	70.79

C = Clutter.
H = Insert Explosives Filled Round.
O = Ordnance.
P = Kinetic Energy Projectile.

When the Open Field Site test is completed, a table similar to Table 8-1 must be submitted except that the geographic coordinates, rather then grid cell number need only be identified for location. An example of the Algorithm Results Table for an open field test is shown in Table 8-2. The spreadsheet will be available on the Standardized Site web page.

TABLE 8-2. SAMPLE PROCESS SENSOR OUTPUT AND ALGORITHM RESULTS DECLARACTION TABLE FOR OPEN FIELD SITE TEST

	Northing	Easting	Response Stage[a]	Discrimination Stage/Ranking[a]	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	14335954.399	1322776.533	0.649	1	C				
2	14335810.267	1322622.501	2.852	76	O	20-mm	1.72	142	-69.40
3	14335769.862	1322340.290	8.209	86	O	105-mm P	0.86	16	-52.10
4	14335723.867	1322372.153	1.757	20	C				
5	14335667.910	1322381.300	0.491	30	C				
6	14335714.842	1322349.533	9.980	89	O	105 H	0.37	140	40.16
7	14336053.513	1322595.982	12.679	15	O	105-mm P	0.28	137	70.79
8	14335753.277	1322309.294	0.577	40	C				
9	14335919.449	1322538.377	4.766	52	O	105-mm P	1.03	297	- 7.13

See footnote and notes on following page.

[a]The two columns (Response Stage and Discrimination Stage) contain an identical number of potential target locations. They differ only in the priority ranking of the declarations.

Notes: Letter and Number - Designate grid location.

Response Stage - Ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. The response stage provides the location and signal strength of all anomalies deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

Discrimination Stage - The ability to correctly identify ordnance as such, and to reject clutter for the same locations as in the response stage anomaly column. The discrimination stage column contains the output of the algorithms applied in the discrimination-stage processing. This column is prioritized based on the determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that provides optimum system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Classification - List O for ordnance or C for clutter. If a distinction is necessary, use P for Kinetic Energy Projectile and H for Inert Explosives Filled Round.

Type - For ordnance list caliber. For clutter leave blank.

Depth - Meters from top of ground to shallowest point of the item.

Azimuth - Relative to magnetic north (0^{o} azimuth indicates nose of the projectile facing magnetic north)

Dip - Relative to the horizontal plane (positive indicates nose of the projectile facing up, 0^{o} indicates the projectile is horizontal, negative indicates nose of the projectile facing down)

SECTION 9. SCORING PROTOCOLS

9.1 INTRODUCTION

This section will outline the objectives, scoring factors, scoring report requirements, scoring terms and definitions, and the layout of the final report. Scoring will be done by ATC utilizing an automated scoring program. All scoring factors will be produced from demonstrator supplied data. In some cases the scoring factors will be rounded to a multiple of five to protect ground truth.

9.2 SCORING OBJECTIVES

The primary objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities under various field and soil conditions.

a. Determine the detection and discrimination under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. Determine costs, time and manpower requirements.

c. Provide an ability to analyze survey data in a timely manner and provide prioritized dig lists with associated confidence levels.

d. Ensure the collection of high quality, ground-truthed, geo-referenced data for post-demonstration analysis.

9.3 SCORING FACTORS

Factors to be measured and evaluated as part of this demonstration include (definitions found in app P):

a. Response Stage Receiver-Operating Characteristic (ROC) curves.

(1) Probability of Detection (P_{det}^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) (Open Field and Scenarios Only).

(4) False Alarm Rate (FAR^{res}) (Blind Test Grid Only).

b. Discrimination Stage ROC curves.

(1) Probability of Detection (P_{det}^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) (Open Field and Scenarios Only).

(4) Probability of Background Alarm (P_{ba}^{disc}) (Blind Test Grid Only).

c. Metrics.

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) P_{det}^{res} , P_{fp}^{res} , BAR^{res} , FAR^{res} , P_{fp}^{disc} , P_{det}^{disc} , BAR^{disc} , P_{ba}^{disc} at each demonstrator's recommended threshold level.

(2) Probability of Detection by Size and Depth.

(3) Classification by Type (i.e., 20-mm, 40-mm, 105-mm, etc.).

(4) Location Accuracy (X, Y).

(5) Depth Accuracy (Z). This will be calculated from the ground surface to the highest point of the item.

(6) Equipment setup and calibration time and man-hour requirements.

(7) Survey time and man-hour requirements for each test area.

(8) Reacquisition/resurvey time and man-hour requirements (if any).

(9) Downtime due to system malfunctions and maintenance requirements.

(10) Comparison of results to date (where applicable).

9.4 DATA REQUIREMENTS FOR SCORING REPORT

9.4.1 Raw Data

While raw sensor data are sensor specific, generally raw data refers to the most rudimentary form of data with the corrected GPS locations applied by the sensor system prior to being subjected to post processing algorithms. (For example, raw data for a magnetometry sensor might be the magnetic flux readings in nano-Tesla relative to time and position, rather than a graphically formed image of these readings.) Raw data will not be released to the public because of the competitive sensitivity of the information. All demonstrators are required to submit raw data prior to departure as a condition for utilizing the site.

9.4.2 Processed Data

9.4.2.1 Blind Test Grid. When the Blind Test Grid is completed, a table similar to Table 9-1 must be submitted. This blank spreadsheet will be available at the Standardized Site web page. A value will be assigned by the demonstrators to designate the threshold value they designate to indicate if an item is ordnance or clutter.

TABLE 9-1. SAMPLE PROCESS ALGORITHM RESULTS DECLARATION FORMAT FOR BLIND TEST GRID

	Grid Letter	Grid Location	Response Stage	Discrimination Stage/Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	A	1	0.649	2	C				
2	A	5	2.852	5	O	20-mm	1.72	142	-69.40
3	A	9	8.209	3	O	105-mm P	0.86	16	-52.10
4	D	3	1.757	9	C				
5	D	11	0.491	0	B				
6	F	2	9.980	52	O	105 H	0.37	140	40.16
7	G	8	12.679	3	O	105-mm P	0.28	137	70.79
8	G	19	0.577	0					
9	H	5	4.766	60	O	105-mm P	1.03	297	- 7.13
10	K	2	0	0					

C = Clutter.
B = Blank.
H = Inert Explosives Filled Round.
O = Ordnance.
P = Kinetic Energy Projectile.

9.4.2.2. Open Field and Scenarios. When the Open Field or a Scenario is completed, a table similar to Table 9-2 must be submitted.

TABLE 9-2. SAMPLE PROCESS ALGORITHM RESULTS DECLARATION FORMAT FOR OPEN FIELD OR A SCENARIO

	Northing	Easting	Response Stage[a]	Discrimination Stage/Ranking[a]	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	14335954.399	1322776.533	0.649	50	C				
2	14335810.267	1322622.501	2.852	36	O	20-mm	1.72	142	-69.40
3	14335769.862	1322340.290	8.209	76	O	105-mm P	0.86	16	-52.10
4	14335723.867	1322372.153	1.757	9	C				
5	14335667.910	1322381.300	0.491						
6	14335714.842	1322349.533	9.980	52	O	105 H	0.37	140	40.16
7	14336053.513	1322595.982	12.679	46	O	105-mm P	0.28	137	70.79
8	14335753.277	1322309.294	0.577	30	C				
9	14335919.449	1322538.377	4.766	60	O	105-mm P	1.03	297	- 7.13
10	14335587.475	1322458.553	.02						

See footnote and notes on following page.

[a]The two columns (Response Stage and Discrimination Stage) contain identical number of potential target locations. They differ only in the priority ranking of the declarations.

Notes: Letter and Number - designate grid location.

Response Stage - Ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. The response stage provides the location and signal strength of all anomalies deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

Discrimination Stage - The ability to correctly identify ordnance as such, and to reject clutter for the same locations as in the response stage anomaly column. The discrimination stage column contains the output of the algorithms applied in the discrimination-stage processing. This column is prioritized based on the determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that provides optimum system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Classification - List O for ordnance or C for clutter. If a distinction is necessary, use P for Kinetic Energy Projectile and H for Inert Explosives Filled Round.

Type - For Ordnance, list caliber. For clutter, leave blank.

Depth - Meters from top of ground to shallowest point of the item.

Azimuth - Relative to magnetic north (0^{o} azimuth indicates nose of the projectile facing magnetic north).

Dip - Relative to the horizontal plane (positive indicates nose of the projectile facing up, 0^{o} indicates the projectile is horizontal, negative indicates nose of the projectile facing down).

9.4.3 Daily Logs

a. During the test, the following data will be recorded by the on-site Project Manager or designee: weather, soil moisture, number of demonstrator’s field personnel, time for each, incidences related to demonstrator’s system reliability, mobilization time, demobilization time, and any other field observations. Enter the information in the ATC digital library.

b. Mobilization time begins when the demonstrator arrives on site and ends when the demonstrator is ready to begin surveying.

c. Demobilization time begins when the demonstrator’s surveying is completed and ends when the demonstrator is ready to leave the site and provide all raw data.

9.4.4 Processing Time

Processing time is the time it takes the demonstrator to submit processed data to the on-site manager after completing a test site. The on-site manager will be responsible for tracking the time it takes each demonstrator to submit processed data.

9.5 DATA PROCESSING, ANALYSIS AND REPORTING

9.5.1 Technical Performance

Scoring will be done by ATC utilizing a computer program that takes the demonstrator's electronically submitted data and compares it to ground truth data. Scoring Factors from paragraph 9.3 will be processed along with corresponding ROC curves into a standard report format.

9.5.2 Cost Performance

Cost analysis will take a uniform approach to quantify the estimated cost for a demonstrator to be out in the field and provide cost penalties for missing or misidentifying ordnance items.

9.6 COMPARISION OF RESULTS

Results will be compared between test scenarios (Blind Grid, Open Field, and Site Specific Scenarios) in order to determine if the feature introduced in each scenario has a degrading effect on the performance of the sensor system. Comparisons are only valid if the equipment, processing, algorithm and sensor settings remain constant. Any change in performance caused by detection equipment changes will be confounded with and indistinguishable from changes in performance due to the scenario feature being tested. Therefore, if the UXO sensor system under test does not change between test scenarios and a statistically significant degradation in performance is seen between test scenarios, then the change in performance will be attributed to the terrain feature that did change between scenarios. The Chi-square test for comparison between ratios will be used at a significance level of 0.05.

9.7 TERMS AND DEFINITIONS

Background Alarm Rejection Rate (R_{BA}): $R_{BA} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})]$): Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

Discrimination Stage evaluates the ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the response stage anomaly list, the discrimination stage list contains the output of the algorithms applied in the discrimination-stage processing.

This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide optimum system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Discrimination Stage Background Alarm (BA^{disc}): A discrimination-stage location outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (# of BA^{disc})/(test area).

Discrimination Stage Probability of Background Alarm ($P_{ba}{}^{disc}$): $P_{ba}{}^{disc}$ = (# of BA^{disc})/(# of empty grid locations)

Discrimination Stage False Positive (fp^{disc}): A discrimination-stage location within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of Detection ($P_{det}{}^{disc}$): $P_{det}{}^{disc}$ = (# of discrimination-stage detections^{disc})/(# of emplaced ordnance in the test site).

Discrimination Stage Probability of False Positive ($P_{fp}{}^{disc}$): $P_{fp}{}^{disc}$ = (#fp^{disc})/(# of emplaced clutter items).

Efficiency (E): $E = P_{det}{}^{disc}(t^{disc})/P_{det}{}^{res}(t_{min}{}^{res})$: Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage (t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}{}^{disc}(t^{disc})/P_{fp}{}^{res}(t_{min}{}^{res})]$: Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage t_{min}). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

R_{halo}: A predetermined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized.

Receiver-Operating Characteristic (ROC) Curves: ROC curves at both the response and discrimination stages can be constructed based on the above open-field definitions. The ROC curves plot the relationship between P_{det} vs. P_{fp} and P_{det} versus BAR as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.

Response Stage evaluates the ability of the demonstrator's system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the response stage, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

Response Stage Background Alarm (BA^{res}): An anomaly from the response stage outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Background Alarm Rate (BAR^{res}): BAR^{res} = (# of BA^{res})/(test area).

Response Stage False Alarm Rate (FAR^{res}): FAR^{res} = (# of BA^{res})/(# of opportunities).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of Detection (P_{det}^{res}): P_{det}^{res} = (# of response-stage detections)/(# of emplaced ordnance in the test site).

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (# of response-stage false positives)/(# of emplaced clutter items).

Threshold: The limit, set on a system's discrimination stage, which defines the difference between what is considered to be ordnance and what is considered clutter. Only those signals that exceed (or fall below, depending on the signal strength polarity) the threshold are considered to result from ordnance.

SECTION 10. STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE CLOSEOUT

10.1 INTRODUCTION

When it becomes necessary to close out the UXO demonstration site, the following procedures will be completed. Site closeout includes removing all inert munitions, steel spheres, copper wire hoops and some of the clutter items placed in the ground during the construction of the site. Natural clutter items should remain in the ground if permitted by local environmental regulations. Site restoration may be required in areas where an issued environmental permit indicates certain action to restore the area to its natural state, i.e. leveling of moguls, planting trees, etc.

10.2 WORK PLAN AND HEALTH AND SAFETY PLAN

A Job Hazard Analysis and Work Plan is prepared in accordance with the host installation health and safety requirements that identifies procedures for removing targets, precautions, and telephone numbers in case of emergency, accident, or site injury. In most cases, the plans developed for site construction may be authorized for use.

10.3 EQUIPMENT/MATERIALS NEEDED TO EXCAVATE THE TARGETS

a. Hand-held DGPS.

b. GPS base station.

c. Shovels.

d. Rakes.

e. Backhoe.

f. Ground truth documentation.

g. Power washer.

h. Placement flags.

10.4 REMOVING EMPLACED TARGETS FROM THE CALIBRATION AND BLIND TEST AREAS

10.4.1 Locate and Remove Targets

a. Locate each target using the information on the Standardized UXO Technology Demonstration Site target placement sheet created when the targets were placed in the ground.

b. Remove the target using a shovel or backhoe.

c. Identify the target item, note the condition and record the date of recovery on the target placement sheet (fig. 3-2). Information on the dip of some of the ordnance items located near the surface should also be recorded.

d. If one of the identification markings are obliterated, tag or mark each ordnance item with the appropriate ATC serial number or the local serial number assigned. If both of the identification markings are obliterated the item should be treated as an UXO.

e. Repeat procedure above until all targets are removed and accounted for.

10.4.2 Recovered Target Items

a. If recovery is required, clutter items will be separated into two groups: recyclables and nonrecyclables. Recyclables will be sent to a recycling processing plant and the nonrecyclables will be disposed of in accordance with local requirements.

b. Items that are considered to be range residue will be recycled separately in accordance with Army guidance.

c. Depending on future use of the inert target munitions, they are to be either recycled according to Army regulations or cleaned-up and shipped back to the Standardized UXO Technology Demonstration Site Target Repository. Contact the ATC UXO Project Manager.

10.4.3 Refill Hole

Backfill the holes using the excavated soil.

10.4.4 Remove PVC Markers

Remove all the PVC markers from the ground.

10.5 REMOVING EMPLACED TARGETS IN THE OPEN FIELD SITE

10.5.1 Locate Targets

Position the GPS base station and check the operation of the hand-held GPS units. Using hand-held GPS units and the Standardized UXO Technology Demonstration Site target placement coordinates (fig. 3-2), flag the points in the field where the target items were buried.

10.5.2 Remove Targets

a. Remove the target using a shovel or backhoe.

b. Identify the target item, note the condition and record the date of recovery on the target placement sheet (fig. 3-2). Information on the dip of some of the ordnance items located near the surface should also be recorded.

c. If one of the identification markings is obliterated, tag or mark each ordnance item with the appropriate ATC serial number or the local serial number assigned. If both of the identification markings are obliterated the item should be treated as an UXO.

d. Repeat procedure above until all targets are removed and accounted for.

10.5.3 Recovered Target Items

Clutter items will be separated into two groups: recyclables and nonrecyclables. Recyclables will be sent to a recycling processing plant and the nonrecyclables will be disposed of in accordance with local requirements.

Items that are considered to be range residue will be recycled separately in accordance with Army guidance.

Depending on future use of the inert target munitions, they are to be either recycled according to Army regulations or cleaned-up and shipped back to the Standardized UXO Technology Demonstration Site Target Repository. Contact the ATC UXO Project Manager.

10.5.4 Refill Hole

Backfill the holes using the excavated soil.

10.6 COMPLETE TARGET PLACEMENT SUMMARY SHEET

Each item extracted from the ground is recorded on the target placement sheet (fig. 3-2) and the target placement spreadsheet (fig. 3-3). The target placement summary sheet is added as an appendix to the closeout report.

10.7 CLOSEOUT REPORT

The closeout report covers all activities relating to the removal emplaced targets, lists the final destination of target items, and contains the completed target placement summary sheet. If any migration of items occurred, it should be noted. The on-site Project Manager for the closed standardized UXO technology site submits the closure report to the ATC Project Manager for review 30 days after site closure. The report is then forwarded to the AEC Program Manager.

SECTION 11. APPENDIXES

APPENDIX A. CLUTTER AND ORDNANCE CHARACTERIZATION

PURPOSE: Provide guidelines for sorting and characterizing clutter/ordnance items.

EQUIPMENT USED: Weighing scales ranging from 0.001 to 50 kg, clear tape, plastic bags, permanent marker, digital camera, 2-inch letter/number cards, wooden crates, and metric ruler.

CLUTTER: Clutter can be a wide variety of items such as nails, soda cans, metallic trash and pieces of ordnance. The majority of the clutter used for the standardized test should consist of UXO related or range debris items. The items selected for emplacing in the field should represent a broad spectrum of weights and sizes. To mimic the wide variety of clutter found in an active site, the ground truth committee came up with six different weight categories. The on-site Project Manager processing the clutter will be given totals for each weight category. They are x <0.25 kg, 0.25<x<0.70 kg, 0.70<x<1.0 kg, 1.0<x<4.0 kg, 4.0 <x<10 kg and x>10 kg. If UXO related clutter is used then it must be certified free of explosives or explosive components.

ORDNANCE: Standardized UXO test site ordnance and some of the nonstandard items will be provided by ATC through AEC. Obtaining site-specific nonstandard ordnance is the responsibility of the on-site Project Manager.

CATEGORIZING: Below is the step-by-step procedure for categorizing both clutter and nonstandard ordnance. Recommend a large space with a few tables as a staging area and large boxes to help segregate clutter after processing. The boxes should be marked according to their weight category.

a. Select either a piece of clutter or ordnance item and bring it to the staging area.

b. Using a blank Field Target Placement Sheet (fig. A-1) assign an identification number to the sheet that will correspond to the item. If the item is marked with a unique identification number then use that number; otherwise, use the following convention.

(1) For clutter (CL-0000)

(2) For nonstandard (NS) ordnance items (NS, type, hyphen and then the number.) For example a nonstandard 81mm mortar would be identified as NS81mm-001.

c. Measure the item and record the following on the Target Placement Sheet.

(1) Length, mm.

(2) Width, mm.

(3) Thickness, mm.

(4) Weight, kg.

(5) Metallurgy.

(6) Additional description if nonstandardized.

d. Place the item on a flat surface and using the lettering/number cards lay out the identification number in front of the item. Take a digital picture of the item and identifier.

e. Mark the item.

(1) If the item is too small to mark with a permanent marker, then place the item in a plastic bag. Write the identification number on the bag and place it the appropriate box.

(2) If the item is clean, not rusted, and has a large smooth surface, using the permanent marker write the identification number directly on the item and place it in the appropriate box.

(3) If the item is rusted and dirty and cannot be written on with a permanent marker, then take the tape and wrap it around the object. On the tape write the identification number and place it in the appropriate box.

f. Repeat a through f until all the items are processed.

Note: When downloading the pictures from the digital camera, make sure the filenames correspond to item identification number.

SPREADSHEET: When all of the Target Placement Sheets have been completed, the digital pictures and the sheets need to be converted into a spreadsheet database. The spreadsheet layout is contained in Figure A-2.

(1) Munitions/Clutter ID number

(2) Item Classification - Inert Ordnance (OR) or Clutter (CL).

(3) Standard/Non-standard - Standard refers to standardized ordnance.

(4) Type - List caliber nomenclature (81-mm) or clutter type (nail, wire, rock, etc.).

(5) Munitions stock/lot number.

(6) Filler Type - Empty, wax, etc.

(7) Material of Item - Steel (St), Aluminum (Al), Magnetic Rock (MAGR), Copper (Cu), Brass (Br). (If the munitions contain more then one material, the material should be correlated with the munitions part; Fuse, Body, or Fins).

(8) Size/Aspect Ratio/Weight.

a. Length, mm.

b. Width, mm.
c. Thickness, mm.
d. Aspect Ratio (length / width) calculated,
e. Weight, grams.
f. Characterization photograph link.
g. Characterization notes.

FIELD TARGET PLACEMENT SHEET

Location: **Aberdeen Proving Ground**

Date: **03/25/01**

Item Classification: **OR** (OR - Inert Ordnance, CL- Clutter item)

Description: **20 mm Projectile**

ID Number for Munition or Clutter **CL-001**

Field Test Area **B** (OF - Open Field, B - blind Test Grid, CAL - Calibration Lanes) (Scenarios E - electrical lines, M - moguls, T - trees, W - wet areas, R - roads)

Additional Description

Grid Location: Grid lane (X-axis number) **14** Grid lane (Y-axis letter)

Depth from surface	**0.23**	m		Clutter Item only:		
Dip	**90**	deg		Length	**53**	mm
Azimuth	**50**	deg		Width	**5**	mm
Northing (UTM)				Thickness	**7**	mm
Easting (UTM)				Weight	**23**	gram
Lat (WGS84)				Type of material	**Metal**	
Long(WGS84)						

Target Photographed: (Y or N) ______

Notes:

Placement certification signature:

Figure A-1. Target placement sheet.

Target Characterization Spread Sheet
Location: Aberdeen Proving Ground Maryland

								Size/Aspect Ratio/Weight						
	Munition or Clutter ID Number	Item Classification	Standard/ Nonstandard	Type	Stock/Lot No.	Filler	Material of Item	Length, mm	Width, mm	Thickness, mm	Aspect Ratio, W/L	Weight, grams	Characterization Photograph	Characterization Notes
1	20-mm-ATC-001	OR	S	20-mm Proj. M39	23467-KL-446	Empty	St	80	19.2		0.24000	130	♦	
2	CL-001	CL		Frag			St	3000	20	20	0.00667	500	♦	
3	CL-002	CL		Rock			MAGR	19	15	11	0.78947	200	♦	
4	81-mm-ATC-001	OR	NS	81-mm Mortar M385	56482-BK-658	Empty	St	506	81		0.16008	4245	♦	
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														

Index

CL = Clutter.	OR = Inert ordnance.	St = Steel.	CU = Copper.	S = Standard.
OF = Open field.	Al = Aluminum.	Br = Brass.	MAGR = Magnetic rock.	NS = Nonstandard.

Figure A-2. Target placement format.

APPENDIX B. MEMORANDUM OF UNDERSTANDING

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE U.S. ARMY ENVIRONMENTAL CENTER
AND
THE (Enter Host Installation Name)

SUBJECT: Standardized UXO Technology Demonstration Site at **(Enter Host Installation Name)**

1. **PURPOSE**. This Memorandum of Understanding (MOU) formalizes a partnership between the U.S. Army Environmental Center (AEC) and the **(Enter Host Installation Name)** in the development and establishment of a Standardized Unexploded Ordnance (UXO) Technology Demonstration Site at **(Enter Host Installation Name)**. This effort will support the UXO community in the evaluation of new sensors, data acquisition, and systems for UXO detection and discrimination.

2. **BACKGROUND**. The AEC is seeking to maximize its ability to transfer UXO sensor technology for Army application. The AEC, located at Aberdeen Proving Ground (Edgewood Area), MD, integrates, coordinates, and oversees implementation of the Army's environmental programs for the Army staff. The AEC provides leadership, focus, direction, and innovative solutions to the Army's future environmental challenges. The AEC has taken the lead in developing innovative solutions to environmental challenges associated with UXO sensor systems performance through the Environmental Security Technology Certification Program (ESTCP) sponsored Standardized UXO Technology Demonstration Program. The AEC is seeking to maximize its ability to transfer UXO sensor technology to commercial demonstrators for application.

The **(Enter Host Installation Name)**, located in **(Enter Host Installation's State)**, conducts testing, experimentation, and evaluation of systems or system components throughout the development cycle; from concept to commercial off-the-shelf. Typical **(Enter Host Installation Name)** test commodities include: combat and tactical vehicles, large and small caliber ordnance, explosives, general support equipment, individual equipment, generators, night vision devices, bridges, mines, countermines, UXO, demolitions, sensors, robotics, environmental technologies, and communications systems. The **(Enter Host Installation Name)** is a multipurpose test center with diverse test capabilities, facilities, and industrial operations. The unique combination of **(Enter Host Installation Name)** experienced personnel, state-of-the-art facilities, instrumentation, equipment, automotive courses, firing ranges, and industrial fabrication/repair capabilities provides a comprehensive facility available for the test and evaluation of a wide variety of innovative environmental technologies.

SUBJECT: Standardized UXO Technology Demonstration Site at **(Enter Host Installation Name)**

The Standardized UXO Technology Demonstration Program is the culmination of a series of efforts to provide locations to evaluate and demonstrate UXO technologies. The Standardized UXO Technology Demonstration Program is building on the lessons learned from all phases of the Jefferson Proving Ground tests, the Fort A.P. Hill Pilot site, and the experiences and expertise of the over 100 individuals participating in the creation and implementation of this program. The creation of the Standardized UXO Technology Demonstration Site at **(Enter Host Installation Name)** will further the understanding of UXO detection and discrimination technologies' capabilities and limitations. The program shall be executed in accordance with the protocols stated in the Standardized UXO Technology Demonstration Site Handbook October 2002 (ref 1).

3. **PROGRAM GOALS**. Based on shared interests and missions, AEC and **(Enter Host Installation Name)** elected to collaborate their environmental quality efforts. This agreement will be beneficial for all parties allowing the participants to explore innovative public/private partnership opportunities. These opportunities include leveraging of technology, equipment, facilities and other resources to achieve shared objectives, and missions.

The Goals of the Standardized UXO Technology Demonstration Site Program are in accordance with the protocols stated in Reference 1 and include but are not limited to:

a. Select designated areas for the Standardized UXO Technology Demonstration Site(s).

b. Execute Standardized UXO Technology Demonstration Program protocols.

c. Develop, operate, and maintain the Standardized UXO Technology Demonstration Site(s).

d. Provide oversight for the demonstration and evaluation of UXO sensor technologies' limitations and capabilities.

e. Complete proper site closeout at the completion of program.

4. **ROLES AND RESPONSIBILITIES**. All parties are responsible for satisfying the roles and responsibilities assigned in the MOU. General roles and responsibilities of this MOU between AEC and **(Enter Host Installation Name)** include:

a. **AEC**

(1) Select a designee of the AEC to serve as the central Program Manager (PM) for identification, coordination, and administration of AEC's and **(Enter Host Installation Name)** interaction for the Standardized UXO Technology Demonstration Site Program.

(2) The PM shall serve as the primary POC for the AEC services, resources, information, and technical assistance as it relates to satisfying the terms of this agreement and in support of the Standardized UXO Technology Demonstration Site Program goals.

(3) Maintain an open line of communication with **(Enter Host Installation Name)** and all of its partners.

(4) Attend and participate in all related programs, meetings, and events.

(5) Promote the U.S. Army's mission and objectives in the demonstration and development of innovative UXO detection and discrimination technologies.

(6) Serve as the primary POC for the transfer of information, data, and results of technologies demonstrations generated from the **(Enter Host Installation Name)** sites.

(7) Provide baseline funding to **(Enter Host Installation Name)** for the program to support initial site development to include UXO clearance, operation and maintenance of the demonstration site; travel and labor costs to attend program meetings and events; data evaluation, site monitoring, programmatic planning, site close out, and technology transfer efforts.

(8) The Standardized UXO Technology Demonstration Site will be returned to conditions comparable to those existing before the initiation of demonstration activities. AEC will only introduce inert standardized targets and clean range-scrap to the site. AEC will not be responsible for contamination discovered as a result of the program.

b. **<u>(Enter Host Installation Name)</u>**

(1) Select an **(Enter Host Installation Name)** designee to serve as the central PM for oversight, coordination, and administration of AEC and **(Enter Host Installation Name)** Standardized UXO Technology Demonstration Site Program interaction.

(2) Provide an on-site PM to oversee and direct activities for each demonstration at **(Enter Host Installation Name)**.

(3) The on-site PM shall serve as the primary POC for all services, resources, safety, information, and technical assistance provided at **(Enter Host Installation Name)** Standardized UXO Technology Demonstration Site.

(4) The Host on-site PMs plan and schedule activities to develop the site in accordance with program plans including UXO clearance and safety.

(5) Attend and participate in all related program meetings and events.

(6) Schedule, operate, and maintain the Standardized UXO Technology Demonstration Site at **(Enter Host Installation Name)** in accordance with the Standardized UXO Technology Demonstration Site protocols.

(7) Coordinate the availability of the **(Enter Host Installation Name)** Standardized UXO Technology Demonstration Site. A 30-day advance notice will be provided by the AEC or the demonstrator to enable coordination to minimize scheduling conflicts with adjacent test activity.

(8) Monitor all demonstrator activities as outlined in the Standardized UXO Technology Demonstration Site Program protocols.

(9) Promote site integrity by limiting use of the Standardized UXO Technology Demonstration Site to authorized demonstrators and excluding this area from other **(Enter Host Installation Name)** uses during the period of this agreement.

(10) Comply with site closeout guidelines as agreed upon in the Standardized UXO Technology Demonstration Site Program protocols.

(11) Will be responsible for addressing regulatory concerns, if any, related to any environmental contamination present at the site, whether in the current form, in any form due to changed circumstances based on the program, or as a result of introduction by the program activities. It is understood that the installation remains responsible for any contamination present at the site.

c. FORCE PROTECTION

a. AEC and **(Enter Host Installation Name)** will designate an individual as a Force Protection Representative (FPR). The FPR will make contact with the installation Force Protection Officer (FPO) prior to or on arrival at **(Enter Host Installation Name)**.

b. The mission of the FPR is to become familiar with the installations Antiterrorism/Force Protection (AT/FP) measures and actions, how the measures and actions effect each organization, and what is required of each organization at the different Force Protection Conditions (FPCONs) in accordance with AR 525-13.

c. The FPR will also become familiar with the Installation Bomb Threat and Bomb Incident Plan and share that knowledge to all individuals within the organization.

5. **EFFECTIVE DATE**. This MOU becomes effective upon signature by both parties, will be reviewed yearly, and shall remain in effect until the completion of the program. Any revisions to this document must be by mutual consent and accomplished in writing.

(**Enter Name)**
Commanding
(Enter Host Installation Name)

Date

STANLEY H. LILLIE
Colonel, CM
U.S. Army Environmental Center

Date

APPENDIX C. PROCEDURES AND EQUIPMENT FOR DEGAUSSING STANDARD TARGETS

This appendix is divided into two parts. Part I contains basic information on degaussing in accordance with military standard MIL-M-19595C. Part II contains the procedure for specific munitions targets.

PART I

DEGAUSSING OF INERT ORDNANCE FOR STANDARDIZED UXO TECHNOLOY DEMONSTRATION SITES

1. GENERAL. Degaussing of inert ordnance for the Standardized UXO Technology Demonstration program will be in accordance with military standard MIL-M-19595C (OS) Amendment 1.

2. EQUIPMENT. Degaussing will be accomplished using the equipment shown in Figure C-1 or C-2 depending on the wall thickness or required penetration depth of the inert ordnance. Figure C-1 is a unit to degauss heavier pieces that require deep penetration. If geometry requires, a special hand made coil (4.0 cable) will be used. Figure C-2 is a unit to degauss smaller items that require little penetration (thin walled ordnance).

Figure C-1. Magnaflux DC rectified Unit, model No. H-6472.

Figure C-2. Magnaflux AC reversing demager, model No. XB-1619.

3. PROCEDURE. The procedure for degaussing is as follows:

a. Section A. Demagnetization

(1) From section 4.5 (Demagnetization - MIL-M-19595C). Demagnetization shall consist of passing each item through more than a 100-oersted peak alternating magnetic field, to a point sufficiently removed where the ambient reading is less than 1 oersted. The motion shall be slow relative to the alternating frequency (several seconds at 60 Hz). The alternating frequency shall be 60 Hz or less. An alternate demagnetization procedure is to slowly reduce to zero the amplitude of the alternating field with the object not moving.

(2) From section 4.4.1.3 (Standard Test Temperature and Background Magnetic Field Limit -MIL-M-19595C). Magnetic effect measurements shall be performed at a temperature of 80 $\pm$ 20 ^{o}F and in a maximum background magnetic field of 450 milli-oersteds. (The background field level is measured when the test object and all other magnetic materials are removed from the vicinity of the detection point.)

b. Section B. To confirm what constitutes a degaussed ordnance item, the following procedure will be used:

(1) Degauss ordnance item along all three axes using procedure in section A above.

(2) Orient a total-field magnetometer parallel to the earth's field (if in the sensors dead-zone, adjust to the point that you get a reading). This procedure should be conducted far away from any outside sources of magnetic noise such as power lines, traffic, or ferrous objects.

(3) Place a nonferrous table or box (like Plexiglas®) over the magnetometer approximately 12 inches ($\pm$0.25 in.) from the center of the sensing element. This structure must be able to support the largest ordnance degaussed.

(4) Rotate the ordnance item around all axes and in different orientations, and record the minimum and maximum readings.

(5) Repeat procedures 1 through 4 until the deltas (difference between the maximum and minimum readings) no longer change. For all practical purposes at this point the ordnance item is as degaussed as possible.

(6) Record the maximum, minimum, and ambient (without ordnance present) magnetic fields.

c. Section C (Problems). If the preceding protocol leaves the ordnance item with a delta reading (minimum/maximum) worse than before:

Perform procedure 3b(3) at a standoff greater than 12 inches. The sensor to ordnance distance should be extended to at least three times the longest dimension of the ordnance.

d. Section D (Issues).

(1) The physical size of the degaussing coil will need to be quite large to accommodate placement of an 8-inch projectile on 3-axis planes while maintaining a 100-oersted field.

(2) The above procedure requires 30 minutes to 1 hour to perform.

(3) Moving, storage and shipment of degaussed items will increase costs.

e. Section E (Definitions and Conversions).

$$1 \text{ gamma} = 10^{-5} \text{ gauss} = 10^{-5} \text{ oersted}^{a} = 10^{-9} \text{ webers/m}^2 = 10^{-9} \text{ tesla}$$

PART II

AMMUNITION DEGAUSSING PROCEDURE

1. EQUIPMENT.

a. Hand-Held Gauss/Tesla Meter, F. W. BELL, model No. 4048.

b. Transverse Probe, F. W. BELL, model No. T-4048-001.

c. Zero Gauss Chamber, F. W. BELL, model No. YA-111.

d. Probe Cable, F. W. BELL, model No. X-4048-002.

e. Magnetic Particle Inspection Station, MAGNAFLUX, model No. H-6472 with DC step-down Demager.

f. 60-Cycle AC Demager, MAGNAFLUX, model No. SB-1619.

g. Wood work table with no ferrite fasteners.

2. CALIBRATION.

a. Turn Tesla Meter on and confirm probe serial number (hit enter).

b. Insert probe into Zero Gauss Chamber and press PB button as you withdraw probe.

c. Allow Tesla Meter to warm up 5 minutes.

d. Press Tesla/Gauss button to convert display to mTesla (mT).

e. Reinsert probe into Zero Gauss Chamber and press PB button as you withdraw probe.

3. INSPECTION PROCESS.

a. Slowly articulate the probe in the air and note the level of background flux.

b. Place a projectile on the table with the fuse end pointing north.

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[a]S. Breiner, Applications Manual for Portable Magnetometers, pg. 6.
Gauss is actually a unit of magnetic induction and oersted a unit of magnetic intensity - B and H respectively, in physics nomenclature. By convention in the geophysical community, however, gauss is the unit in cgs of magnetic intensity.

c. Place probe at approximately 45^{o} with the probe tip touching the projectile on the north end, rotate the probe until a negative reading is obtained then mark the upper surface of the probe (to establish proper polarity). When display stabilizes write down reading.

d. Place probe at approximately 45^{o} with the probe tip touching the projectile on the south end and rotate probe so marked side is down. When the display stabilizes with a positive reading, write down reading.

e. Place probe at approximately 45^{o} with probe tip touching the projectile mid section (length), rotate from the marked to the unmarked side then write down the highest reading.

f. Rotate the projectile on the table so the fuze end points south and repeat procedures c, d and e.

g. Probe placement is identified for each projectile photographically (see attached photos).

4. VALUES FOR 20-MM, 40-MM, 57-MM, 60-MM and 81-MM PROJECTILES.

a. No reading shall exceed the background reading + 0.03 mT.

b. The variation between readings shall not exceed 0.03 mT.

c. If readings exceed those in paragraph 4a and/or 4b, place the projectile on 60-cycle AC demagnetization (demag) tray and pull through the coil while energized and repeat section 3. Repeat this process until readings are compliant with paragraphs 4a and 4b.

5. VALUES FOR 105-MM, 155-MM and 8-INCH PROJECTILES.

a. No reading shall exceed the background reading + 0.05 mT.

b. The variation between readings shall not exceed 0.05 mT.

c. If readings exceed those in paragraph 5a and/or 5b, place the projectile on DC coil with the fuze extending 15.24 cm (6 in.) beyond the coil and energize the coil (demag cycle). At the completion of the cycle move the projectile 20.32 cm (8 in.) into the coil (fuze now 35.56 cm (14 in.) from coil) and energize the coil. Repeat this process until less than 20.32 cm (8 in.) of the projectile is in the coil. Repeat section 3.

d. If acceptable readings cannot be achieved it may be necessary to remove the fuze and/or base from the projectile body. Degauss these components separately using the 60-cycle AC demag tray. Repeat this process until readings are compliant with 5a and 5b. Then repeat section 5c without the fuze and/or base attached. Repeat this process until the projectile body readings are compliant with paragraphs 5a and 5b.

e. Reassemble the fuze and/or base and repeat section 3. If readings are still in excess of paragraphs 5a and 5b remove the fuze and/or base and repeat sections 5c and 5d.

APPENDIX D. UXO WORK PLAN AND HEALTH AND SAFETY PLAN

1. GENERAL. The UXO contractor is required to submit a company approved Standing Operating Procedure (UXO Work Plan and Health and Safety Plan (HSP)) to the Standardized UXO Technology Demonstration Site on-site Project Manager. The HSP will be included in the host installation's Standardized UXO Technology Demonstration Site Job Hazard Analysis and Work Plan. A UXO crew is not required for areas designated to be free of UXO by the host installation. However, the same principles for clearing non-energetic material from the site apply. Work will still be in accordance with the host installation health and safety requirements. The work in an UXO area will involve:

a. Initial UXO and clutter clearance to 0.6 meter, digging, identification, recording findings, and removal.

b. Down Holing. UXO clearance beyond 0.6 meter for auger, geo-probes, and target emplacement.

c. Post survey digs from a GPS dig list, identification, records of findings, and removal.

d. Post investigation work that may require additional digs, identification, recording findings, and removal.

Removal of any UXO will be in accordance with established explosive ordnance disposal (EOD) procedures and the host installation requirements. In the Calibration Lanes/Ground Test Pit and Blind Test Grid, all anomalies detected (including any questionable ones) will be investigated to ensure that these areas have been cleared of debris/UXO and clutter to the highest degree of confidence possible. A lesser degree of confidence in the removal of abnormalities is acceptable for the Open Field Site because of the latitude of target emplacement in this area. Listed below are requirements for the work noted above.

2. PREREQUISITE FOR UXO CONTRACTOR.

a. The company must be UXO certified and the personnel must have the qualifications listed in the skill hierarchy of the draft memorandum, Subject: Implementation of Contractor Unexploded Ordnance Personnel Qualification Standards (fig. D-1)

b. The approved contractor must be familiar with the installation/military policies for UXO handling/removal.

3. INITIAL CLEARING. The goal is to remove and identify all electrically conductive/ permeable items within the UXO test area to a maximum depth of 0.6 meter.

3.1 Method of Clearing the UXO Test Site.

If vegetation exists, and it is safe to do so, mow the vegetation to a height of 15 cm (approximately 6 in.) prior to the work crew coming on site.

a. The area under consideration for the test sites will be sectioned off into 30-meter squares and marked using white pin flags with nonmetallic post. Each cell within the grid will be numbered for clearing quality control.

b. Starting in the first cell use a passive ferrous metals magnetometer with the instrument sensitivity set on the highest sensitivity range practicable and sweep the grid in a north-south direction and excavate any anomaly when detected. Sweep the same cell using an electromagnetic (active all-metal) inductive detector in an east-west direction and excavate any anomaly when detected. Follow up with a third sweep of the cell using either of the above instruments. This sweep is conducted diagonally across the cell as a quality control check. Excavate any anomalies detected. If more than three "hits" are detected during the quality control check, this entire process must be repeated. Follow this procedure for all cells in the test site grid. Approved detection instruments are listed below.

c. Two types of instruments (passive magnetometer and active electromagnetic induction) will be used.

(1) Magnetometer with some level of signature response to depth. Models capable of conducting the survey include but are not limited to the following: Schnostedt GA-52-B and GA-72CV, Geometrics G 858 Magnetometer, and Forster Ferex 4.021 (upgraded Ferex 4.021 MK26 with digital capabilities).

(2) Electromagnetic Detector. Models capable of conducting the survey include but are not limited to the following: White Metal Detectors (Eagle II SL 90), Fisher Metal Detectors (1266XB, CZ7), Geonics EM61 Time-Domain Metal Detector, Geonics EM61 MK2, Geonics EM61 HH, Geophex GEM-3 Sensor, and Geometrics GTEM Metal Mapper.

d. Both types of instruments will not be used at the same time on the Calibration Lanes/Ground Test Pit and Blind Test Grid, or within 100 meters of each other on the Open Field Site.

e. Radios are prohibited on the UXO personnel conducting the sweep.

3.2 The UXO crew will:

a. Sweep one grid at a time, excavating any anomalies when detected.

b. Dig the anomaly (hit) and remove or clear the item(s), following standard UXO procedures and the local installation/military requirements for UXO removal.

c. Record all debris/UXO items found and the total number of anomalies excavated in each grid on a daily basis.

d. Save some of the clutter items found for use in the Blind Test Grid or Open Field Site.

e. Refill all holes that were created during the clearing process with soil and/or grass and seed area.

f. Move to the next grid and repeat the process in paragraphs a through e above until all grids have been completed.

g. Clear the area to be used as the Ground Test Pit as described in section 4B, paragraph 4B.3.4.

4. CLEARANCE OF HOLES PRIOR TO GEO-PROBE ACTIVITY. UXO Crew will:

a. Using UXO avoidance technique, within 0.6 meter of the proposed core-sampling hole, hand auger down to the required depth of approximately 2.4 meters in 0.6-meter intervals.

b. Any anomaly detected should be investigated and removed. If the anomaly is below 1.2 meters and removal may be a problem at the time, relocate to an adjacent area and try again.

c. Fill in the hole(s) after it has been determined the area is free and clear of any debris/UXO and mark the location(s).

d. Report to on-site Project Manager any holes that have been abandoned because of an unclearable anomaly. More information can be found in Appendix H.

5. DIG LIST GPS AND POST SURVEY DIGS. The UXO crew will be given a dig list (table D-1) with pertinent information of any hits (anomalies) from the multisensor towed array detection system (MTADS) or equivalent scanning device of the Calibration Lanes/Ground Test Pit, Blind Test Grid, and Open Field Site.

a. The UXO crew using GPS will locate and flag (yellow) all hits from the Dig List.

b. The UXO crew then will:

(1) Dig all hits and remove all items, following established EOD procedures and local installation/military policies for UXO removal.

(2) Record information on the items found (table D-1).

(3) Save some of the clutter items found for later use in the Calibration Lanes, Blind Test Grid or Open Field Site.

(4) Refill all holes that were created during the clearing process with soil and/or grass, and reseed.

TABLE D-1. SAMPLE DIG LIST

Demonstrator One: MTADS EM

Ranking	Northing, m	Easting, m	Depth, m	Type	Confidence	Size/ Weight	Azimuth, deg	Dip, deg	Class	Type
001	4309738.557	641594.2038	0.91440	Ordnance	High	Large	180	20	Projectile	152-mm
050	4309689.964	641519.4151	0.89042	Ordnance	Low	Small	-	-	Projectile	Unknown
165	4309700.031	641516.8877	0.82296	Clutter	High	Medium	-	-	Fragment	-

6. TARGET EMPLACEMENT. In the Calibration Lanes and Blind Test Grid, the target emplacement will always be in the center of a grid. All target emplacements will be by ERDC as specified by the on-site Project Manager. The UXO crew, if required, will clear any anomalies found during target emplacement.

7. POST INVESTIGATIVE WORK. The debris/UXO crew, at the direction of the on-site Project Manager, will investigate any reported detected unexplained anomalies that may have occurred during a demonstrator's test program. This will require debris/UXO crew to:

a. Respond to the request to investigate.

b. Dig any hits and remove all items, following the local installation/military policies for UXO removal.

c. Record information on any items removed (table D-1).

UXO CONTRACTOR QAUILIFICATIONS

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Implementation of Contractor Unexploded Ordnance Personnel Qualification Standards

1. Reference: Deputy Under Secretary of Defense (DUSD) Environmental Security (ES) memorandum, subject Department of Defense (DOD) Certified Course.

2. This memorandum:

a. Provides the qualification standards (enclosure) for contract unexploded ordnance (UXO) personnel developed by the Joint-Service Integrated Product Team and Office of the Secretary of Defense (OSD) Department of Defense Explosives Safety Board (Department of Defense Explosives Safety Board (DDESB) Secretariat).

b. Provides authorization for these qualification standards to be used within the Army.

3. The use of these qualification standards applies to all Department of the Army (DA) entities conducting operations involving unexploded ordnance (UXO), range clearance operations, range maintenance, range residue inspection, certification or verification or any other operation where UXO may be encountered, to include non-emergency response actions. These standards apply to operations conducted both on and off an installation. Contract UXO personnel shall meet the minimum training and experience specified in the enclosure commensurate with the specific work they will be contracted to perform.

4. These standards will be implemented to the maximum extent contractually allowable on existing contracts involving UXO operations. Future contracts involving UXO personnel will fully implement these standards.

5. DA ODCSLOG's (DALO-AMA) point of contact is Mr. Leo Shanley XXX or MAJ (U.S. Army Reserves (USAR)) Bayuga XXXXXXX.

SIGNATURE BLOCK
Installation Commander

Figure D-1. Draft memorandum.

Skill Hierarchy

The following information sets forth the skill hierarchy appropriate to those individuals performing UXO remediation. (Note: The Department of Labor standards reflect a UXO Safety Escort who will simply provide escort services for site visitors. The IPT recommends deletion of this position as a UXO Technician I (or higher) level person can provide this capability. There is no value added in having a specific position for this function.) Table 1 outlines minimum years EOD/UXO experience for each position and special requirements.

1. UXO SWEEP PERSONNEL. Sweep personnel assist UXO technicians and supervisory personnel in the clearance of UXO, operating only under the direct working supervision of qualified UXO technicians and/or UXO supervisors. Sweep personnel will:

a. Conduct visual and/or instrumented UXO search activities in the field.

b. Operate ordnance detection instruments and other similar equipment.

c. Remove nonhazardous scrap (e.g., fuze remnants, fragments, and related debris) only after such items have been certified/verified by a qualified UXO technician as safe for handling.

d. Sweep personnel are not involved in the execution of explosives operations.

e. This position requires site and job specific contractor training (which may include ordnance recognition, safety precautions, donning and doffing of protective clothing, etc.) but does not require UXO technician qualifications.

f. Perform field maintenance on military and/or civilian magnetometers.

2. UXO TECHNICIAN I. This skill level allows the individual to assist fully qualified personnel (UXO Technician II and above) in the following functions:

a. Conducting reconnaissance and classification of UXO.

b. Identification of all ordnance types and condition, armed or unarmed, to include:

(1) Bombs and bomb fuzes (to include munition and fuze condition - armed or unarmed).

(2) Guided missiles.

(3) Projectiles and projectile fuzes (to include fuze condition - armed or unarmed).

(4) Rockets and rocket fuzes (to include fuze condition - armed or unarmed).

(5) Land mines and associated components.

Figure D-1. Draft memorandum (cont'd).

(6) Pyrotechnic items.

(7) Military explosives and demolition materials.

(8) Grenades and grenade fuzes (to include fuze condition - armed or unarmed).

(9) Submunitions.

c. Location of subsurface UXO using military and/or civilian magnetometers (and related equipment).

d. Performing excavation procedures on subsurface UXO.

e. Locate surface UXO by visual means.

f. Transportation of UXO and demolition materials.

g. Preparation of firing systems, both electric and nonelectric, for disposal operations (not render safe procedures).

h. Operation of personnel decontamination stations.

i. Inspection of salvaged UXO related material and the erection of UXO related protective works.

j. Perform field maintenance on military and/or civilian magnetometers.

k. Must be able to don and doff personnel protective clothing.

3. UXO TECHNICIAN II. Must be able to fully perform all of the functions enumerated in Sweep Personnel and UXO Technician I plus:

a. Properly store explosive materials in accordance with applicable guidance.

b. Determine a magnetic azimuth using current navigational/locating equipment.

c. Perform field expedient identification procedures to identify contaminated soil.

d. Prepare an on-site holding area for recovered UXO.

e. Operate modes of transportation for transporting UXO, when appropriate.

f. Perform limited technical supervision of nontechnical personnel.

Figure D-1. Draft memorandum (cont’d).

4. UXO TECHNICIAN III. Must be able to fully perform all of the functions enumerated in Sweep Personnel, UXO Technicians I and II plus:

a. Supervise and perform the on-site disposal of recovered UXO and demolition materials.

b. Prepare an explosive storage plan in accordance with all applicable guidance.

c. Prepare required UXO remediation administrative reports.

d. Prepare Standard Operating Procedures (SOPs) for on-site remediation project.

e. Perform risk, hazard analysis.

f. Conduct daily site safety briefings.

g. Supervise the conduct of all on-site evolutions directly related to UXO remediation.

5. SENIOR UXO SUPERVISOR. Must be able to fully perform all of the functions enumerated in Sweep Personnel, UXO Technicians I, II, and III plus:

a. Perform planning, coordinating, and supervision of all UXO activities.

b. Supervise multiple UXO teams performing:

(1) Reconnaissance and classification of UXO pyrotechnic items, military explosives and demolition materials.

(2) Locating surface and subsurface UXO.

(3) Destruction of UXO by burning and detonation.

(4) Transporting and storing UXO.

c. Prepare SOPs for UXO remediation actions ensuring compliance with DOD directives as well as local, state, federal, and statutes and codes.

d. Certify AEDA and/or range scrap as ready for disposal or turn-in in accordance with current policies.

6. UXO QUALITY CONTROL SPECIALIST. Must be able to fully perform all of the functions enumerated in Sweep Personnel, UXO Technicians I, II, and III plus:

a. Implement the UXO specific sections of the Quality Control Program for all UXO related evolutions.

Figure D-1. Draft memorandum (cont'd).

b. Conducts quality control audits of all UXO and explosives operations for compliance with established procedures.

c. Identify and ensure completion of all corrective actions to ensure all UXO related work complies with stipulated contractual requirements.

7. UXO SAFETY OFFICER. Must be able to fully perform all of the functions enumerated in Sweep Personnel, UXO Technicians I, II, and III plus:

a. Implement the approved explosives and UXO safety program in compliance with all DOD, federal, state, and local statutes and codes.

b. Analyze UXO and explosives operational risks, hazards and safety requirements.

c. Establish and ensure compliance with all site-specific safety requirements for UXO and explosives operations.

d. Enforce personnel limits, safety exclusion zones for UXO clearance operations, UXO and explosives transportation, storage, and destruction.

e. Conduct safety inspections to ensure compliance with all UXO and explosives safety codes.

f. Operate and maintain air-monitoring equipment required at site for airborne contaminates.

g. Ensure all equipment utilized within the exclusion zone is operated in accordance with federal, state, and local statutes and codes.

Figure D-1. Draft memorandum (cont'd).

TABLE 1. QUALIFICATION STANDARDS FOR UXO WORKERS

Position Description	Notes	Minimum Years EOD/UXO Experience (Notes 4 and 5)	Special Requirements
UXO Safety Officer	1 and 2	8	Experience in all phases of UXO remediation and applicable safety standards. Will be directly hired by and work for the prime contractor and must report directly to the Project Manager or someone higher in the contractor's organization. Will not be involved in any removal or investigation tasks.
UXO Quality Control Specialist	1 and 2	8	Experience in all phases of UXO remediation and the transportation, handling and storage of ordnance and explosives materials. Will be directly hired by and work for the prime contractor and must report directly to the Project Manager or someone higher in the contractor's organization. Will not be involved in any removal or investigation tasks.
Senior UXO Supervisor	1 and 2	10	Significant experience in all aspects of UXO remediation. Five years experience in supervisory positions.
UXO Technician III	1, 2 or 3	8	Prior military EOD or commercial UXO experience. Plus specific project or ordnance training.
UXO Technician II	1 and 2 or 3	0	Prior military EOD experience.
		3	Experience in UXO remediation or range clearance operations. Plus specific project ordnance training.
UXO Technician I	3	0	Successfully completed approved course of instruction appropriate to this skill level.
UXO Sweep Personnel	Equipment and site specific training	NA	Equipment and site specific training. (Experience at this position is not required for UXO Technician I certification.)

Notes:
1. Graduate of the Army Bomb Disposal School at Aberdeen, MD.
2. Graduate of the Naval EOD School.
3. Graduate of a Department of Defense certified EOD Assistant or UXO Training Program.
4. For computational purposes of UXO contractor time, 1 year is equal to 1740 paid hours.
5. These are the minimum experience requirements for designation. This is not an automatic designation, but reserved for those who have demonstrated the requisite knowledge, maturity, and judgment and are recommended by the contractor for recognition.

Figure D-1. Draft memorandum (cont'd).

APPENDIX E. SITE SURVEY

Topographic Site Characterization Protocols

1. PURPOSE. Establish guideline/protocols for topographic site characterization at the Standardized UXO Technology Demonstration Sites.

2. GENERAL. Topographic site characterization consists of two primary activities. First, adequate and accurate control survey markers must be established on the site. The second activity consists of collecting sufficient and accurate elevation terrain and position data on features within the terrain to generate a Digital Terrain/Elevation Model (DTEM). An associated activity requires that the direction of magnetic north be established so that additional geophysical characterizations may be performed. It is recommended that this be accomplished using a standardized model such as the National Geodetic Survey (NGS) Magnetic Declination Model.

3. CONTROL MARK REQUIREMENTS. This control should consist of four or more survey markers located within the site boundaries and should be surveyed to an accuracy of 5.0 cm horizontally (2-D). Elevation accuracy should be established to a standard of 10 cm. This degree of accuracy is necessary due to the incorporation of GPS into many UXO detection systems. UXO surveys also require accurate control data for precise positioning of sensor data and possible data fusion. The coordinate data must also use standard real world coordinate systems (NAD83 Datum Northing/Easting UTM format), since many GPS systems are unable to convert to local coordinates. Multiple markers are necessary for two reasons. First, multiple users may operate at the site simultaneously. Second, sensor systems without internal positioning systems may be tracked using systems such as the ERDC S-Tracker[1], acoustic or other conventional terrestrial survey systems which use multiple tracking devices operating from known locations. Each marker need not have complete line-of-sight coverage of the entire test site; however, one or two other control markers should be visible from each control marker.

4. TERRAIN CHARACTERIZATION SURVEY REQUIREMENTS. Topographic and terrain feature data are required to efficiently plan site characterization, modifications and target placements. Topographic elevation data should be collected to a 0.3036-meter (1-ft) accuracy and 5-meters (16 ft) horizontal grid spacing. Features within the site (trees, power lines, roads, etc.) should also be mapped to this same vertical and horizontal standard. A sufficient number of points should be collected on each feature to accurately delineate and position the feature (i.e., tree drip line should be mapped as opposed to tree trunk location). Single coordinate points may be sufficient on features such as utility poles.

[1]S-Tracker is a tracking system that incorporates Real-Time Kinematic GPS positions with positions generated using multiple robotic total station surveying systems to accurately track UXO sensor platforms.

APPENDIX F. SPECIFICATIONS ON FIRST ORDER MARKER AND UTM FORMAT

1. GENERAL. Marker/Control Point/Benchmark Information is as follows:

a. Use NAD83 Northing/Easting UTM format to find positions. A standard design for benchmark/survey marker/control points is shown below[1]. The concrete should be extended down to approximately 10 cm below the frost line and the survey disc embedded level on the surface of the concrete slab.

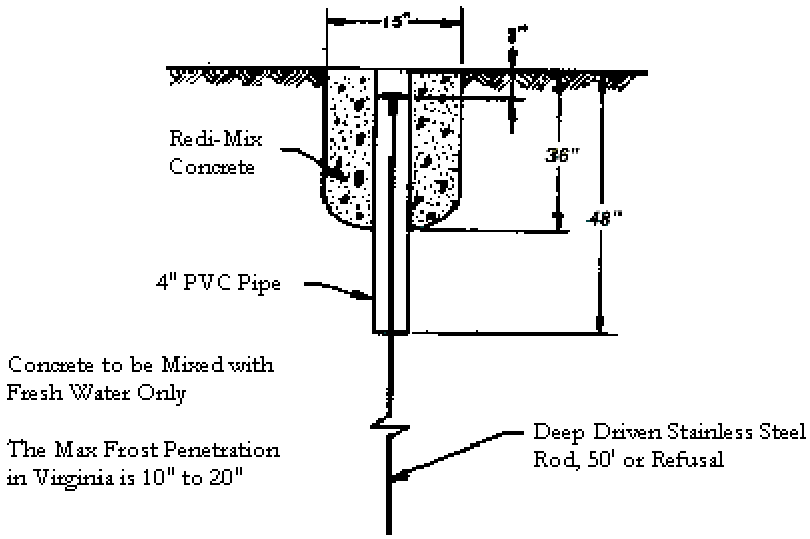


Figure F-1. Recommended control point design.

b. First Order Marker. Usually several survey markers are required at one of these sites (typically three to four) based on the size of the site, topography, and vegetation. Each survey marker should be constructed to the minimum standards for first order control points (as shown above). Coordinates should be established by conducting surveys to first order standards with minimum requirements of 1:100,000 accuracy or 5.0 cm whichever is greater. GPS surveys meeting first order standards will provide, theoretically, an elevation accurate to 2.5 cm and this is more than sufficient to meet the vertical accuracy standards described in Appendix E. However, differential leveling should be performed between survey markers on-site to ensure accurate relative elevation data.

2. REFERENCE.

Reilly, J.P., (2001), The GPS Observer, POB, Vol 26(4).

[1]Gatto, L.W. (1987). “Benchmark Design and Installation, A Synthesis of Existing Information,” Special Report 87-10, U.S. CERLY, Hanover, NH

APPENDIX G. SECONDARY DEBRIS CLEARANCE

1. PURPOSE. Establish guidelines/protocols for secondary debris clearing of the Standardized UXO Technology Demonstration Site.

2. GENERAL. The secondary ground survey checks the performance of the initial debris clearance and identifies objects that need further investigation for all the standardized sites. The two pieces of survey equipment used for secondary clearance are an EM sensor and magnetometer. Naval Research Laboratory, using a MTADS, will conduct the secondary ground survey. This system is designed to cover large areas quickly and at depths up to 2 meters, depending on soil conditions.

3. FIELD HARDWARE. Briefly, the system hardware consists of a low-magnetic-signature vehicle that is used to tow linear arrays of magnetometer and pulsed-induction sensors to conduct surveys of large areas to detect buried debris. The MTADS tow vehicle, manufactured by Chenowth Racing Vehicles, is a custom-built off-road vehicle, specifically modified to have an extremely low magnetic signature. Most ferrous components have been removed from the body, drive train and engine and replaced with nonferrous alloys. The pulsed-induction sensors (specially modified model EM-61s from Geonics) are deployed as an overlapping array of three sensors on a nonmetallic trailer, Figure G-1. Similar to the towed vehicle is a hand held EM portable detector as shown in Figure G-2. These sensors transmit a short electromagnetic pulse into the earth. Metallic objects interact with this transmitted field, which induces secondary fields in the object.

Figure G-1. MTAD's tow vehicle and pulse-induction array deployed.

Figure G-2. EM portable.

These secondary fields are detected by six detection coils that are co-located with and above the transmit coils. The sensors employed by MTADS have been modified to make them more compatible with vehicular speeds; the transmit frequency is increased and the analog time constant is decreased, and to increase detection sensitivity to small objects, the transmit power and amplifier gain are increased and the sampling window is moved closer to the transmit pulse. The output of the pulsed-induction sensors is sampled at 10 Hz which combined with a typical

survey speed of 4.8 km/hr, results in a sampling interval of ~15 cm along track with an across track spacing of 0.5 meter.

Depending on the surrounding area of the Standardized UXO Technology Demonstration Site such as military equipment, steel fences, parked cars, electrical lines and buildings, the pulsed induction sensors are the survey instrument of choice for near-surface surveys. These sensors are much less susceptible to interference from nearby metal objects such as fences. They are active sensors that require two-way travel of the electromagnetic excitation so their sensitivity falls off relatively quickly with depth. For objects deeper than 2 meters, the other MTADS sensor choice, passive magnetometers, is required. The MTADS magnetometers are Cesium-vapor full-field magnetometers (Geometric model No. 822ROV) selected for low noise, a small dead zone, and intersensor reproducibility. An array of eight sensors is deployed as a magnetometer array on an aluminum and composite platform (fig. G-3). Sensors are sampled at 50 Hz and typical surveys conducted at 6 mph; this results in a sampling density of ~6 cm along track with a sensor spacing of 25 cm. A ninth sensor deployed at a static site removed from the survey area measures the time-variation of the earth's field. These data are used to correct the survey magnetic readings. The sensor positions are measured in real-time (5 Hz) using the latest real time kinematic (RTK) GPS technology which results in position accuracies of ~5 cm. All navigation and sensor data are time-stamped with UTC derived from the satellite clocks and recorded by the data acquisition computer (DAQ) in the tow vehicle. The sensor, position, and timing files are downloaded periodically throughout a survey onto magnetic disks and transferred to the Data Analysis System (DAS) for analysis.

Figure G-3. The MTADS magnetometer array.

4. SURVEY NAVIGATIONAL CONTROL. The MTADS sensor location system relies on differential corrections radioed from a GPS receiver at a known (first order, if possible) base station to the vehicular system for its accuracy. In many instances, particularly at remote field sites, a commercial surveyor prior to the MTADS survey establishes these reference positions.

5. DATA ANALYSIS SYSTEM. The MTADS Data Analysis System converts the sensor and position data files into an anomaly map by interpolating the individual sensor readings using the GPS-derived positions. The DAS software was developed specifically for the MTADS program as a stand-alone suite of programs in a UNIX environment. The data collected during the survey

are analyzed using a workstation; PC-based code is also available and is being integrated into the field operations. The DAS is written for use by both sophisticated and novice users. Even the novice can perform a complete anomaly analysis using menu-driven tools and default settings. For the advanced user, there is an extensive range of options available including navigation data cleanup, sensor nulling and leveling, noise filtering, etc. The working screen of the DAS is shown in Figure G-4. In the case of ordnance targets in the far field (i.e., farther from the sensors than their characteristic dimension) the DAS employs resident physics-based models to determine target size, position, and depth. Extensive data sets have been acquired and processed to calibrate these models. These analysis capabilities are not applicable to large, shallow targets such as the potential targets located from historical documents that are the subject of this survey. In these cases, target anomaly maps are used to estimate the position and physical size of the anomaly and, in the case of the pulsed-induction sensors, the relative response of the upper and lower receive coils is used to estimate depth.

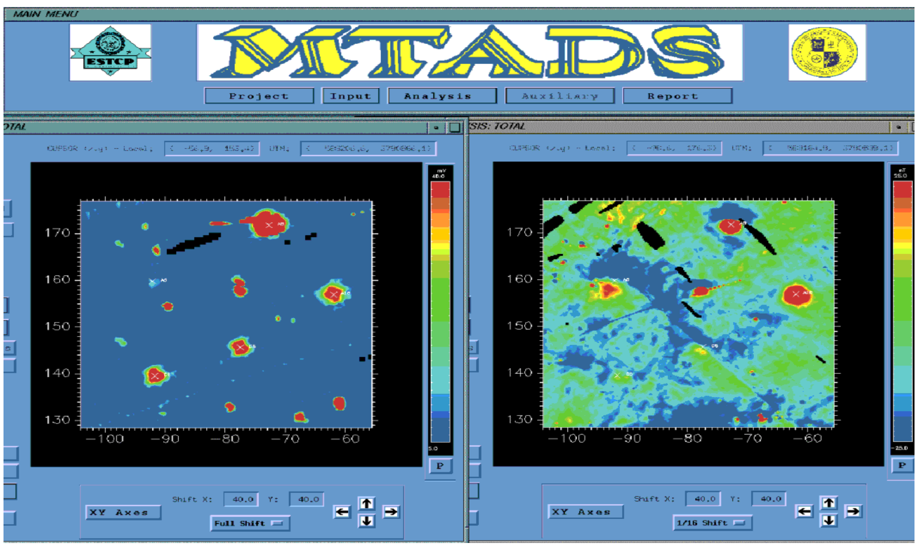


Figure G-4. Data analysis system with the site view and target analysis windows visible.

6. FIELD SURVEYING. Field operations are conducted using a standard protocol. The first task each day is set up of the GPS reference station (antenna, receiver, battery, and radio). If a magnetometer survey will be conducted, the magnetometer reference station to be used for diurnal corrections is set up and started. Concurrently with these operations, the vehicle driver initializes the data acquisition computer and sensors and collects a short data set that includes sequential excitation of the sensors with a standard target. This data set is transferred to the DAS and examined by the operator for correct placement and operation of the sensors.

Magnetometer surveys are conducted driving back and forth across the field to be surveyed using a lane spacing of approximately 1.75 meters. This gives one-sensor overlap of the survey tracks and ensures good survey coverage. The vehicle operator following his wheel tracks accomplishes survey guidance, if possible, or, if the tracks are not visible, by marking the track to be surveyed with rubber cones. In the best case, surveys are conducted east and west to

minimize influence of the vehicle on the sensors. If this is not convenient, north-south tracks are used and the residual vehicle signature is removed from the DAS.

Pulsed-induction surveys are conducted in a similar manner. The survey speed is half that of a magnetometer survey and there is no inherent preference for survey direction. If the goal of the pulsed-induction survey is detection alone, a single survey is sufficient. It has been noted at other sites, that discrimination ability is markedly improved if another survey driven at right angles to the first is conducted. In this case, the data from both surveys are analyzed concurrently in the DAS.

For both systems, individual data collection periods are limited to 1 hour to minimize surveying with an undetected system malfunction. At the end of the first hour, data are transferred to the DAS for a quality check. After this, the surveys are broken into 1-hour segments and transferred to the DAS at noon and at the end of the day. Diurnal magnetometer data are likewise collected at noon and at the end of the day for correlation with field survey data.

At the conclusion of each day's survey operation, the base stations are secured, vehicle and remote sensor batteries put on charge for the evening, and the Data Analysis Computer is backed up onto removable media. From this, the data will be processed using DAS software. A dig list will be produced (table G-1).

TABLE G-1. DIG LIST

DIG LIST: 1. Demonstrator: MTADS EM. Test Area: 1. Including 20 mm ?: No.

Ranking	Northing, m	Easting, m	Depth, m	Type, Ordnance/ Clutter	Confidence	Size/ Weight	Azimuth, deg	Inclination, deg	Class	Type
001	4309738.557	641594.2038	0.9144	Ordnance	High	Large	180	20	Projectile	152 mm
-										
-										
-										
-										
-										
050	4309689.964	641519.4151	0.89042	Ordnance	Low	Small	-	-	Projectile	unknown
-										
-										
165	4309700.031	641516.8877	0.82296	Clutter	High	Medium	-	-	Fragment	-

7. REFERENCE.

MTADS Geophysical Survey of Potential Underground Storage Tank Sites at the Naval District Washington Anacostia Annex, J. R. McDould, H. H. Nelson, and Richard Robertson, NRL/MR/6110-00-8435.

APPENDIX H. SOIL SAMPLING AND ANALYSIS

(Page H-2 Blank)

1. PURPOSE. Establishes guidelines for soils sampling, soils characterization and testing, and sample preservation and disposition at the Standardized UXO Technology Demonstration Sites.

2. GENERAL. Soil samples will be acquired at sites selected for development under the Standardized UXO Technology Demonstration Site Program. The soil samples are part of the comprehensive geological and geophysical characterization of the sites supporting future demonstrations of UXO detection and discrimination technologies on the sites. Soil sampling provides vertical and horizontal assessment of soil types/classifications, water/moisture contents, particle size gradation, and laboratory measurement of geophysical properties. Both near-surface grab samples and nominal 3-meter continuous core samples will be acquired. Deeper sampling (e.g., 6 m) may be required when site specific munitions (bombs, large caliber artillery) with greater depth are being investigated.

The sampling sites, if located in an UXO contaminated area, will be cleared of any UXO to the maximum sampling depth prior to any soil sampling activities. Surface sampling will not be done until the initial surface clearing as described in Appendix D, paragraph 3 is complete. The UXO avoidance technique in Appendix D, paragraph 4 will be used for all deep core samples.

3. SPATIAL DISTRIBUTION. Sampling locations will be systematically placed over the Open Field Site, Calibration Lanes, and Blind Test Grid to sample the areas by (1) soil types, (2) topography, and (3) vegetation (Butler, Llopis, and Simms, 1999). Vertical sampling/boring location density will be a minimum of one location per soil type or one per acre, whichever is greater. Where possible, the sampling locations will be nominally aligned along profile lines (for vertical cross-section visualization). For example, an Open Field Site of approximately 13 acres will have a minimum of 12 soil boring locations. Near-surface grab samples collected at a depth of 5 cm will be acquired at locations intermediate to the soil boring locations in a manner to maximize the spatial coverage of the areas. An example of the soil sampling strategy for the three APG test site areas is illustrated in Figure H-1. For the soil boring locations, eight samples will be selected for testing at nominal depths of 0.05, 0.25, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 meters. The ERDC, Waterways Experiment Station (WES) is responsible for designing the soil sampling plan at each selected Standardized UXO Technology Demonstration Site.

4. SAMPLE ACQUISITION. The nominal 3-meter continuous soil sampling will be accomplished using a drill rig with a split spoon soil sampler, Geoprobe push sampler, or other sampling system capable of acquiring continuous soil samples. It is preferred that the sampling tube be lined with a PVC (clear) or clear plastic liner to facilitate geophysical and other laboratory tests. The soil sample will have a minimum diameter of 38 mm (1.5 in.) but not to exceed 76 mm (3 in.). The nominal 3-meter continuous soil sample may be acquired in sections to accommodate sampling tube and/or liner length, and handling and shipping considerations. Any vegetation at the location of the soil boring is to be removed prior to collecting the sample. The near-surface samples obtained at a 5-cm depth should be collected using a clean, corrosion-free tool, such as a shovel or hand soil core sampler. The quantity of soil collected should fill a 0.9-liter (1-qt) jar or a 0.9-liter (1-qt) plastic bag.

Nominal Soil Sampling Locations for APG UXO Test Site

✷ -- Vertical soil boring

✢ -- Surface soil sample

Vertical Boring Sample Depths for Testing

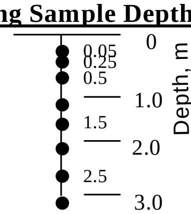


Figure H-1. Nominal soil sampling locations for the APG site.

5. SAMPLE STORAGE. The nominal 3-meter continuous samples shall be sealed to preserve moisture content consistent with accepted soil sampling practice (U.S. Army Corps of Engineers 1996; ASTM Standards 1995), either in plastic sleeves or wax-coated cardboard tubes. Near-surface soil grab samples will be placed in mason jars and sealed.

The primary method for storing the continuous soil samples is in a PVC (clear) or in a clear plastic liner placed in the drill stem at the time the soil sample is collected. Upon removal of the soil core, the plastic liner shall be capped using plastic caps and the caps secured with duct tape. If plastic liners are not compatible with the soil-sampling rig, then the soil core will be placed in clear plastic tubes (same diameter as soil core) immediately upon removal of the soil sample from the drill sample tube. The plastic tube shall be capped and taped. A plug should be placed in the tube to prevent sliding of the soil when the tube is moved if the soil core does not fill the plastic tube. If a plastic liner or tube is not suitable for storing the soil sample, a wax-coated cardboard tube can be used.

The near-surface soil samples can be stored in either a 0.9-liter (1-qrt) rubber-seal jar (e.g., mason jar) or in a 0.9-liter (1-qt) resealable (e.g., ziplock), heavy duty (i.e., freezer) plastic bag. The rubber-seal should be clean and secured firmly to the jar. A soil sample stored in a plastic bag should be double bagged, with the air forced out of the bag containing the soil, sealed, and then placed in another sealed bag.

Both the continuous soil core samples (all sections) and the near-surface samples shall be labeled, using an indelible marker, with the following information:

a. Date.

b Time.

c. Location of the Standardized UXO Technology Demonstration Site.

d. Grid Location.

e. Test Site (Calibration Lanes, Blind Test Grid, or Open Field Site).

f. Sample Depth or Depth Range.

g. Number of Containers for the Sample (e.g., 1 of 2, 2 of 2).

Figure H-2 is an example of a label (51 by 102 mm) with required information that can be printed on a self-adhesive page (e.g., manufactured by Avery, label size 5163). If the near-surface samples are stored in plastic bags, then both bags should be labeled.

Date: Time:
Test Site: [ ] APG [ ] YPG (check one)

Area: [ ] Calibration Lane [ ] Blind Test Grid [ ] Open Field Site (check one)

Grid Location (Northing/Easting) X Y

Sample Depth or Depth Range

Sample of

Figure H-2. Example of a core sample label.

6. LOGBOOK RECORD. A record of the soil sample will be recorded in a logbook at the time the sample is collected. The information recorded should include: (a) name of the individual(s) collecting the soil sample, (b) organization or company performing the soil sampling, (c) type of drill rig/tool used to recover the sample, (d) type of container the soil is stored in, plus (e)

information listed under sample storage.

7. PACKING AND TRANSPORTING. The company or organization contracted to collect the soil samples is responsible for packaging and shipping of the samples. The soil samples shall be well packed in a sturdy container to minimize damage during transport. Ship all samples via overnight delivery on the same day they are collected, if possible.

All soil samples should be shipped to:

ERDC Waterways Experiment Station
ATTN: Janet Simms, Bldg 3396
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. SOILS TESTING. All soil samples will be visually classified and tested to determine water content (percent by weight) according to standard soils testing procedures (U.S. Army Corps of Engineers 1970). Moisture content determination shall be done on the 3-meter continuous samples at depths of 0.05, 0.25, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 meters. Additionally, soil samples from the 3-meter continuous sampling locations will be tested to determine particle-size gradation (sieve and hydrometer) and formal unified soil classification (Casagrande 1948). To the extent possible, representative bulk densities of intact soil samples in tubes or sleeves will be determined, and subsequently volumetric water contents can be calculated.

Mineral identification using X-ray diffraction shall be performed on select soil samples taken from the 3-meter continuous samples.

Magnetic susceptibility of the continuous samples will be measured as a function of depth prior to removing any samples from the sample tubes, and sufficient quantities of each soil sample will be reserved to support future detailed laboratory measurements of magnetic susceptibility and dielectric permittivity. The dielectric permittivity measurements will include profiles of both the quadrature (ε') and inphase (ε'') components as a function of depth, frequency, and water content.

The soils testing will be performed by the Geotechnical and Structures Laboratory, ERDC WES.

9. REFERENCES.

a. ASTM Standards 1995, Annual Book of ASTM Standards, Volume 4.08, D 4220-95.

b. Casagrande, A. 1948, Classification and Identification of Soils, Transactions of the American Society of Civil Engineers, 113: 901-991.

c. U.S. Army Corps of Engineers 1970, Laboratory Soils Testing, Engineer Manual EM 1110-2-1906, 30 November 1970 with Change 2, 20 August 1986, U.S. Army Corps of Engineers, Washington, DC.

d. U.S. Army Corps of Engineers 1996, Soil Sampling, Engineer Manual EM 1110-1-1906, 30 September 1996, U.S. Army Corps of Engineers, Washington, DC.

APPENDIX I. BASELINE SURVEY

(Page I-2 Blank)

Geophysical Site Characterization Protocols

1. PURPOSE. Establish guidelines/protocols for geophysical site characterization at the Standardized UXO Technology Demonstration Sites.

2. GENERAL. A geophysical backgrounds characterization of the Standardized UXO Technology Demonstration Sites will be performed by the ERDC, WES. The site characterization will serve as archival documentation for any future use of the sites and for comparison to past and future UXO/mine detection investigations. The geophysical methods to characterize the sites include magnetic, EM, electrical resistivity, ground penetrating radar (GPR), magnetic susceptibility, and seismic refraction. These are standard geophysical techniques and a theoretical description can be found in such texts as Telford et al. (1990), U.S. Army Corps of Engineers (1979, 1995), and Burger (1992).

The sites will be surface cleared of any UXO (if located in an UXO contaminated area) and metallic debris prior to the geophysical site characterization activities.

Each geophysical method is described in the following pages of this appendix in tabular format, giving the resulting property obtained, minimum data acquisition criteria, final survey product, and minimum equipment specifications. Table I-1 summarizes the maximum line spacing and minimum data sampling for each method when performed in the Calibration Lanes, Blind Test Grid, and Open Field Site. An illustration of a possible data collection scenario for the resistivity and seismic profiles in the Calibration Lanes, Blind Test Grid, and Open Field Site at APG is given in Figure I-1.

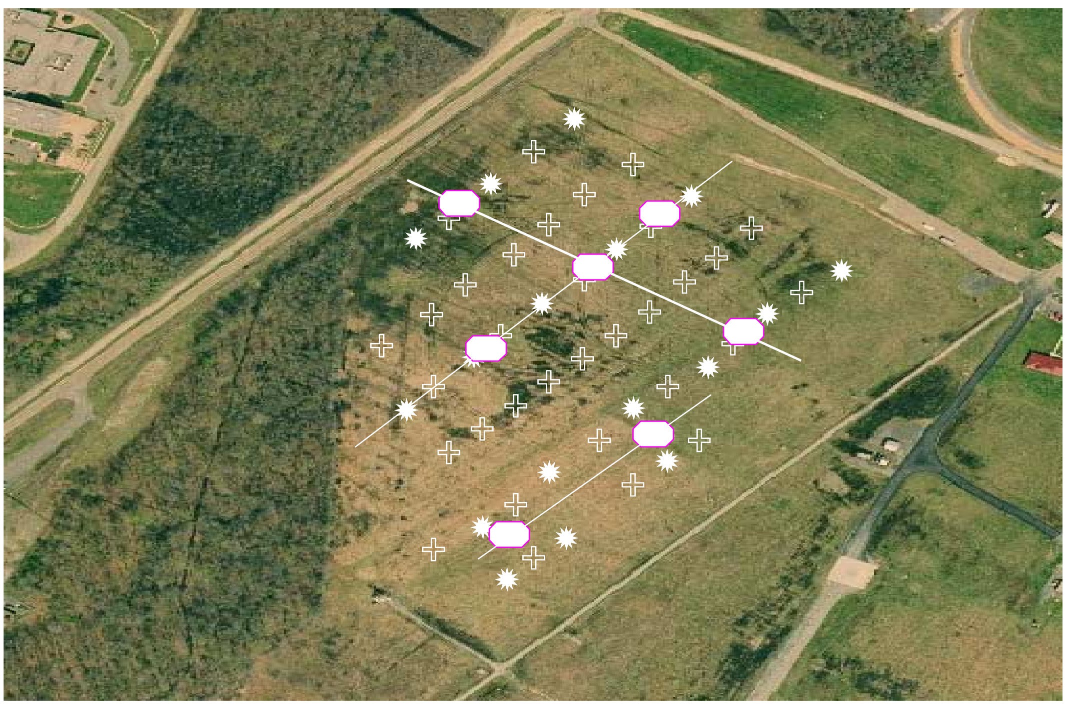
TABLE I-1. SUMMARY OF GEOPHYSICAL SURVEYS

		Calibration Lanes (2000-sq m area)		**Blind Test Grid (4000-sq m Area)**		**Open Field Site (Approx 4.05 Hectares)**	
Geophysical Survey	**Measured Components**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**
Magnetic	Total Field	1	3	1	3	10	2
EM31	QP, IP (vertical comp.)	2	3	2	3	10	2
EM61	Top, Bottom Channel	1	3	1	3	-	-
EM38	QP, IP (vertical comp.)	1	3	-	-	-	-
	Property	Comments					
Resistivity VES	Apparent Resistivity	Minimum AB spacing 100 meters; preferably centered at a soil boring location; orthogonal sounding where doesn't cross other soil types; number of VES dependent on site size: Open field grid, minimum one set of orthogonal VES per hectare; calibration and blind grids, minimum one VES.					
GPR	Dielectric Permittivity EM Wave Velocity	Calibration and blind grids only; profiles along target centerlines; antenna frequencies 50, 100, 200/225/250, 450/500, 900 MHz.					
DICON Probe	Dielectric Permittivity	60 MHz response at each soil sample location (boring and near-surface samples); measurements at depths of 0.05, 0.25, and 0.5 meter.					

TABLE I-1. (CONT'D)

		Calibration Lanes (2000-sq m area)		Blind Test Grid (4000-sq m Area)		Open Field Site (Approx 4.05 Hectares)	
Geophysical Survey	**Measured Components**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**	**Maximum Line Spacing, m**	**Minimum Data Sampling, sample/m**
Magnetic Susceptibility Bartington MS2D	Magnetic Susceptibility	At each soil sample location (boring and near-surface samples); surface measurement.					
Magnetic Susceptibility EM38	Magnetic Susceptibility	At each soil sample location (boring and near-surface samples); greater volume of investigation than MS2.					
Seismic Refraction	Material Velocity	Number of profile lines dependent on site size; open field grid, minimum one profile line per hectare; calibration and blind grids, minimum one profile line.					

Soil Sample, Resistively Profile, and Seismic Profile Locations for APG UXO Test Site



Vertical soil boring — VES Profile Center
Surface soil sample — Seismic Profile

Figure I-1. An illustration of soil sample, resistivity and seismic profile locations at the APG Standardized UXO Technology Demonstration Site.

3. MAGNETIC TOTAL FIELD.

Note: If MTADS performs the secondary sweep and no significant anomalies were detected on the survey, then the survey data (EM61 top and bottom channel data) will be used as the background characterization data set.

a. Objectives.

(1) Measure the local earth's magnetic field strength.

(2) Characterize any local/regional trends prior to any site disturbance.

(3) Locate any large buried ferrous-metallic objects prior to site disturbance.

b. Procedures.

(1) Measurements on lines spaced 1 meter (Calibration Lanes and Blind Test Grids) or 10 meters (Open Field Site) apart with an approximate 0.3-meter spacing along lines.

(2) Maximum mobile sensor height, 0.5 meter.

(3) Base station used to correct for diurnal variations.

(4) Final products are diurnal and base station reference value corrected contour maps of magnetic total field in nanotesla (nT).

c. Equipment.

(1) Geometrics G-858 Cesium Magnetometer and G-856 Proton Precession Base Station Magnetometer or equivalent.

(2) Range 17,000 to 100,000 nT.

(3) Accuracy $\pm$1 nT; Sensitivity $\pm$0.05 nT at 1-second cycle rate.

4. EM SURVEY, FREQUENCY DOMAIN.

a. Objectives.

(1) Determine terrain (apparent) electrical conductivity distribution over the site.

(2) Determine volume averaged electrical conductivity of subsurface materials.

(3) Measure quadrature phase (conductivity) and in-phase (sensitive to metallic objects) components of EM field.

b. Procedures.

(1) EM31.

(a) Measurements acquired along lines spaced at 2 meters (Calibration Lanes and Blind Test Grid) or 10 meters (Open Field Site) with approximately 0.3-meter spacing along lines.

(b) Maximum sensor height, 1 meter.

(c) Nominal depth of investigation, 5 meters.

(2) EM38 (Calibration Lanes).

(a) Measurements acquired along lines spaced at 1 meter with approximately 0.3-meter spacing along lines.

(b) Maximum sensor height, ground surface.

(c) Nominal depth of investigation, 1.5 meters.

c. Equipment.

(1) Geonics EM31.

(a) 9.8 kHz operating frequency (frequency domain system).

(b) Conductivity range, 1 to greater than 1000 millisiemen per meter (ms/m).

(c) Typical measurement accuracy is 5 percent at 20 ms/m.

(d) Noise Levels: Quadrature, 0.1 ms/m; In-Phase, 0.03 part per thousand (ppt).

(e) Final products are contour maps of conductivity (ms/m) and in-phase response (ppt).

(2) Geonics EM38.

(a) 14.6 kHz operating frequency (frequency domain system).

(b) Conductivity range, 0.1 to greater than 1000 ms/m.

(c) Measurement precision, $\pm$0.1 percent of full-scale deflection.

(d) Final products are contour maps of conductivity (ms/m) and in-phase response (ppt).

5. EM SURVEY, TIME DOMAIN (CALIBRATION LANES AND BLIND TEST GRIDS ONLY).

Note: When MTADS performs the secondary sweep and no significant anomalies are detected on the survey, then the survey data (EM61 top and bottom channel data) will be used as the background characterization data set.

a. Objectives.

(1) Determine presence of metallic objects.

(2) Measure two channels (top and bottom) of response (in millivolts (mV)).

b. Procedures.

(1) Measurements acquired along lines spaced at 1 meter with approximately 0.3-meter spacing along lines.

(2) Nominal depth of investigation, 3 meters.

c. Equipment.

(1) Geonics EM61.

(2) Coil size, 1 by 1 meter or 1 by 0.5 meter.

(3) Final products are contour maps of top, bottom, and differential channels in mV.

6. VERTICAL ELECTRICAL RESISTIVITY SOUNDINGS (VES).

a. Objectives.

(1) Determine depths to phreatic zone.

(2) Determine depths to layers with contrasting electrical properties. (Example, sand versus clay.)

(3) Determine electrical resistivity (= 1/conductivity) of subsurface materials.

b. Procedures.

(1) Planned depth of investigation, approximately 10 meters.

(2) VES planned in intersecting (orthogonal) lines; preferred that VES are centered at soil boring locations; number of VES dependent on size of site: Open Field Site, minimum one set of orthogonal VES per hectare; Calibration Lanes and Blind Test Grid, minimum one VES.

(3) Final product is a vertical electrical profile (i.e., electrical resistivity versus depth at locations along intersecting lines).

(4) Inversion using INTERPEX software.

b. Equipment. ABEM SAS 300B or STING electrical resistivity meter and Schlumberger array or equivalent.

c. Accuracy.

(1) Interpreted depths to interfaces typically accurate to 10 percent of depth.

(2) Interpreted resistivities accurate typically to 10 percent of resistivity.

7. GPR SURVEY (CALIBRATION LANES AND BLIND TEST GRIDS ONLY).

a. Objectives.

(1) Determine subsurface stratigraphy; assess heterogeneity.

(2) Detect material layers and other objects with contrasting electrical/dielectric properties.

(3) Determine EM wave speeds and bulk dielectric permittivity.

b. Procedures.

(1) Performed after magnetic and EM anomalies have been removed from the Calibration Lanes and Blind Test Grid and prior to burial of targets.

(2) Several transmitters (Tx) to be used - 50, 100, 200/225/250, 450/500 and 900 MHz center frequencies.

(3) Tx-receiver (Rx) spacing held fixed at spacing depending on frequency and desired depth of investigation.

(4) Depth of investigation dependent on antenna frequency and electrical conductivity of soil, typically 1/3 to 10 meters.

(5) GPR profiles shall be performed along each centerline the targets will be located in both the Calibration Lanes and Blind Test Grid; if an anomaly is detected for a given antenna frequency, then the anomaly location will be investigated by designated personnel. After investigation of the anomaly, only the disturbed area is required to be resurveyed with the given antenna, not the entire centerline profile.

(6) WARR/CMP soundings to determine EM wave speeds as function of frequency and site location and bulk dielectric permittivity

b. Equipment.

(1) Sensors and Software, Inc., PulseEKKO IV/100 and/or PulseEKKO 1000 and/or Noggin (Pulsed or Time-Domain GPR's) or equivalent.

(2) Sensors and Software, Inc., data processing software and U.S. Geological Survey (USGS)/WES full waveform modeling capabilities.

8. DICON PROBE.

a. Objectives.

(1) Obtain in situ EM measurements (60 MHz).

(2) Determine relative dielectric permittivity (real), conductivity, and wave speed.

b. Procedures.

(1) Collect data at soil sample locations (borings and near-surface samples).

(2) Measurements at depths of 0.05, 0.25, and 0.5 meter (soil conditions permitting).

(3) Compare EM data with that obtained from GPR and laboratory analyses of soil.

c. Equipment. DICON Probe (WES) or equivalent.

9. MAGNETIC SUSCEPTIBILITY.

a. Objectives.

(1) Determine natural variation of near-surface magnetic susceptibility.

(2) Identify naturally occurring magnetic anomalies.

(3) Determine magnetic susceptibility variations at ground surface and in upper half meter of soil.

b. Procedures.

(1) Bartington MS2D.

(a) Measurement at each soil boring and near-surface soil sample location. Provides magnetic susceptibility value at ground surface.

(b) Clear surface vegetation to accommodate sensor coil.

(c) Average of three measurements made at ground surface.

(2) Geonics EM38.

(a) Measurement at each soil boring and near-surface soil sample location. Provides magnetic susceptibility value of upper half meter of soil.

(b) Follow procedure given in EM38 Operating Manual (Geonics 1998).

c. Equipment.

(1) Bartington MS2D.

(a) Comparison between the permeability of free space and the relative permeability obtained with the added contribution of the sample magnetic susceptibility (Bartington Instruments, Ltd.).

(b) Measures concentration of ferrimagnetic minerals in the top circa 60 mm of the ground surface (Bartington Instruments, Ltd.).

(c) Operating frequency, 0.958 kHz.

(d) Maximum resolution, 2 by 10^{-7} Coastal Geodetic Survey (CGS) (depending on environmental conditions).

(e) Temperature induced drift, 1 by 10^{-6} CGS/^{o}C typical.

(f) Search loop, 185-mm diameter.

(2) Geonics EM38. Refer to EM Survey, Frequency Domain above.

10. SEISMIC REFRACTION.

a. Objectives.

(1) Determine depth to saturated material.

(2) Determine thicknesses of subsurface layers with contrasting seismic velocities.

(3) Determine topography of interfaces between layers.

(4) Determine P- and S-wave seismic velocities.

b. Procedures.

(1) Planned depth of investigation, approximately 10 meters.

(2) Number of profile lines dependent on size of site: Open Field Site, minimum one profile line per hectare; Calibration Lanes and Blind Test Grid, minimum one profile line; preferable to have VES, GPR, and seismic profile lines coincide.

(3) Geophone spacing, varying from 0.5 to 3 meters.

(4) Final products are two-dimensional cross-sections.

(5) Interpretations using ERDC's SEISMO and RIMROCK's SIPT software.

c. Equipment. 24-channel EG&G seismograph; 8-Hz geophones; hammer (impulsive) source or explosives (if needed) or equivalent.

d. Accuracy.

(1) Interpreted depths to interfaces accurate to better than 10 percent of the depth.

(2) Interpreted seismic velocities accurate to 5 percent of velocity or better (dependent on heterogeneity of site).

11. DATA INTEGRATION. The electrical resistivity, seismic refraction, GPR and soil sample analysis results will be integrated to form geologic cross sections of the sites. Detailed analyses of the GPR results will give a qualitative high-resolution assessment of shallow geologic heterogeneity, detailed shallow stratigraphy, and location and assessment of localized features. The magnetic total field, EM terrain conductivity, and EM in-phase results will give an assessment of the (1) presence of shallow, buried large ferrous metallic objects, (2) presence of metallic or other localized conducting zones, (3) variation of bulk conductivity across the sites, and (4) local regional variation of the magnetic field across the sites.

12. REFERENCES.

a. ASTM Standards 1995, Annual Book of ASTM Standards, Volume 4.08, D 4220-95.

b. Bartington Instruments, Ltd., Operating Manual for MS2 Magnetic Susceptibility System, OM0408, OI0408 Issue 18.

c. Burger, H. R., 1992, Exploration Geophysics of the Shallow Subsurface, Prentice Hall, New Jersey.

d. Casagrande, A., 1948, Classification and Identification of Soils, Transactions of the American Society of Civil Engineers, 113: 901-991.

e. Geonics 1998, EM38 Ground Conductivity Meter Dual Output Version Operating Manual, January 1998, Geonics Limited, Mississauga, Ontario.

f. Telford, W. M., Geldart, L. P., and Sheriff, R. E., 1990, Applied Geophysics, Cambridge University Press, New York.

g. U.S. Army Corps of Engineers 1970, Laboratory Soils Testing, Engineer Manual EM 1110-2-1906, 30 November 1970 with Change 2, 20 August 1986, U.S. Army Corps of Engineers, Washington, DC.

h. U.S. Army Corps of Engineers 1979, Geophysical Exploration, Engineer Manual EM 1110-1-1802, 31 May 1979, U.S. Army Corps of Engineers, Washington, DC.

i. U.S. Army Corps of Engineers 1995, Geophysical Exploration for Engineering and Environmental Investigations, Engineer Manual EM 1110-1-1802, 31 August 1995, U.S. Army Corps of Engineers, Washington, DC.

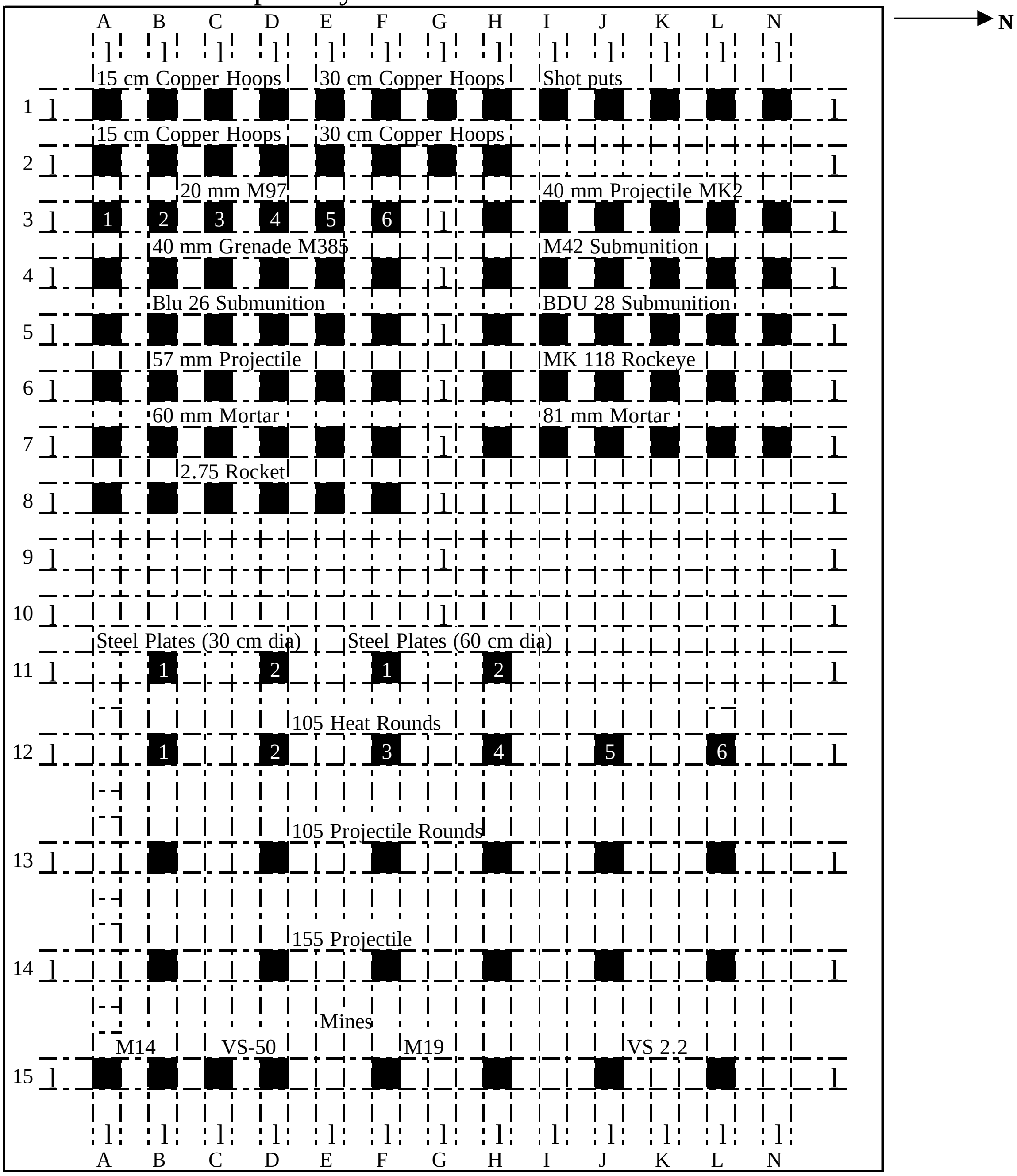
j. U.S. Army Corps of Engineers 1996, Soil Sampling, Engineer Manual EM 1110-1-1906, 30 September 1996, U.S. Army Corps of Engineers, Washington, DC.

APPENDIX J. CALIBRATION LANES LAYOUT

Calibration Lanes							
	Depth, m	Az, deg	Dip, deg		Depth, m	Az, deg	Dip, deg
20-mm Projectile (M55)				**40-mm Grenades (M385)**			
Calculated Depth	0.61	-	-	**Calculated Depth**	0.20	-	-
Recovered Depth	0.15	-	-	**Recovered Depth**	NA	-	-
20-mm Projectile (M55)	0.10	0	45	40-mm Grenades (M385)	0.10	0	45
20-mm Projectile (M55)	0.10	0	-45	40-mm Grenades (M385)	0.10	0	-45
20-mm Projectile (M55)	0.10	0	90	40-mm Grenades (M385)	0.10	0	90
20-mm Projectile (M55)	0.10	0	-90	40-mm Grenades (M385)	0.10	0	-90
20-mm Projectile (M55)	0.20	0	0	40-mm Grenades (M385)	0.20	0	0
20-mm Projectile (M55)	0.20	180	0	40-mm Grenades (M385)	0.20	180	0
20-mm Projectile (M55)	-	-	-	40-mm Grenades (M385)	-	-	-
MK 118 ROCKEYE				**M42 Submunition**			
Calculated Depth	0.61	-	-	**Calculated Depth**	0.50	-	-
Recovered Depth	NA	-	-	**Recovered Depth**	NA	-	-
MK 118 ROCKEYE	0.30	0	45	M42 Submunition	0.25	0	45
MK 118 ROCKEYE	0.30	0	-45	M42 Submunition	0.25	0	-45
MK 118 ROCKEYE	0.30	0	90	M42 Submunition	0.25	0	90
MK 118 ROCKEYE	0.30	0	-90	M42 Submunition	0.25	0	-90
MK 118 ROCKEYE	0.60	0	0	M42 Submunition	0.25	0	0
MK 118 ROCKEYE	0.60	180	0	M42 Submunition	0.25	180	0
MK 118 ROCKEYE	-	-	-	M42 Submunition	-	-	-
BLU-26 Submunition				**BDU-28 Submunition**			
Calculated Depth	0.20	-	-	**Calculated Depth**	0.20	-	-
Recovered Depth	-	-	-	**Recovered Depth**	-	-	-
BLU-26 Submunition	0.10	0	0	BLU-28 Submunition	0.10	0	45
BLU-26 Submunition	0.20	0	0	BLU-28 Submunition	0.10	0	-45
BLU-26 Submunition	0.30	0	0	BLU-28 Submunition	0.10	0	90
BLU-26 Submunition	-	-	-	BLU-28 Submunition	0.10	0	-90
2.75-Inch Rocket M230				BLU-28 Submunition	0.20	0	0
Calculated Depth	1.20	-	-	BLU-28 Submunition	0.20	180	0
Recovered Depth	-	-	-	BLU-28 Submunition	-	-	-
2.75-Inch Rocket M230	0.50	0	45	**57-mm Projectile APC M86**			
2.75-Inch Rocket M230	0.50	0	-45	**Calculated Depth**	0.91	-	-
2.75-Inch Rocket M230	0.50	0	90	**Recovered Depth**	0.76	-	-
2.75-Inch Rocket M230	0.50	0	-90	57-mm Projectile APC M86	0.40	0	45
2.75-Inch Rocket M230	1.20	0	0	57-mm Projectile APC M87	0.40	0	-45
2.75-Inch Rocket M230	1.20	180	0	57-mm Projectile APC M88	0.40	0	90
2.75-Inch Rocket M230	-	-	-	57-mm Projectile APC M89	0.40	0	-90
60-mm Mortar M49A3				57-mm Projectile APC M90	0.91	0	0
Calculated Depth	1.20	-	-	57-mm Projectile APC M91	0.91	180	0
Recovered Depth	0.46	-	-	57mm Projectile APC M92	-	-	-
60-mm Mortar M49A3	0.50	0	45	**81-mm Mortar M374**			
60-mm Mortar M49A3	0.50	0	-45	**Calculated Depth**	1.50	-	-
60-mm Mortar M49A3	0.50	0	90	**Recovered Depth**	1.06	-	-
60-mm Mortar M49A3	1.00	0	-90	81-mm Mortar M374	0.50	0	45

Calibration Lanes							
	Depth, m	Az, deg	Dip, deg		Depth, m	Az, deg	Dip, deg
60-mm Mortar M49A3	1.00	0	0	81-mm Mortar M374	0.50	0	-45
60-mm Mortar M49A3				**81-mm Mortar M374**			
60-mm Mortar M49A3	1.00	180	0	81-mm Mortar M374	0.50	0	90
60-mm Mortar M49A3	-	-	-	81-mm Mortar M374	0.50	0	-90
105-mm Projectile M60				81-mm Mortar M374	1.50	0	0
Calculated Depth	1.80	-	-	81-mm Mortar M374	1.50	180	0
105-mm Projectile M60	0.40	0	45	81-mm Mortar M374	-	-	-
105-mm Projectile M60	0.40	0	-45	**105-mm HEAT Rounds M456**			
105-mm Projectile M60	0.40	0	90	**Calculated Depth**	0.80	**-**	**-**
105-mm Projectile M60	0.40	0	-90	105-mm HEAT Rounds M456	0.40	0	45
105-mm Projectile M61	0.80	0	0	105-mm HEAT Rounds M456	0.40	0	-45
105-mm Projectile M62	0.80	180	0	105-mm HEAT Rounds M456	0.40	0	90
105-mm Projectile M63	-	-	-	105-mm HEAT Rounds M456	0.40	0	-90
155-mm Projectile M483A1				105-mm HEAT Rounds M456	0.80	0	0
Calculated Depth	2.00	-	-	105-mm HEAT Rounds M456	0.80	180	0
Recovered Depth	0.91	-	-	105-mm HEAT Rounds M456	-	-	-
155-mm Projectile M483A1	0.40	0	45	**Steel Plates**			
155-mm Projectile M483A1	0.40	0	-45	30-cm diameter	0.50	-	-
155-mm Projectile M483A1	0.40	0	90	30-cm diameter	1.00	-	-
155-mm Projectile M483A1	0.40	0	-90	60-cm diameter	0.50	-	-
155-mm Projectile M483A1	0.80	0	0	60-cm diameter	1.00	-	-
155-mm Projectile M483A1	0.80	180	0	**Shot Put**			
155-mm Projectile M483A1	-	-	-	5.4 kg	0.50	-	-
Wire Hoops				5.4 kg	1.00	-	-
12-Wire Gauge (30 cm)	0.25	0	0	5.4 kg	1.50	-	-
12-Wire Gauge (30 cm)	0.25	0	90	5.4 kg	2.00	-	-
12-Wire Gauge (15 cm)	0.25	0	0				
12-Wire Gauge (15 cm)	0.25	0	90				
16-Wire Gauge (30 cm)	0.25	0	0				
16-Wire Gauge (30 cm)	0.25	0	90				
16-Wire Gauge (15 cm)	0.25	0	0				
16-Wire Gauge (15 cm)	0.25	0	90				
18-Wire Gauge (30 cm)	0.25	0	0				
18-Wire Gauge (30 cm)	0.25	0	90				
18-Wire Gauge (15 cm)	0.25	0	0				
18-Wire Gauge (15 cm)	0.25	0	90				
20-Wire Gauge (30 cm)	0.25	0	0				
20-Wire Gauge (30 cm)	0.25	0	90				
20-Wire Gauge (15 cm)	0.25	0	0				
20-Wire Gauge (15 cm)	0.25	0	90				

Example Layout of the Calibration Lanes



Key

1. Horizontal, N-S, maxium

2. Horizontal, E-W, maxium

3. 45^o,N-S, Mid-point (nose down)

Markers (shot puts)

4. 45^o,N-S, Mid-point (nose up)

5. 90^o,0, Mid-point (nose up)

6. 90^o,0, Mid-point (nose down)

1 meter Grid

APPENDIX K. TARGET EMPLACEMENT (AUGER)

1. PURPOSE. To establish guidelines for emplacing targets using auger system.

2. EQUIPMENT.

a. Two-Man Auger or Bobcat Auger.

b. Hand Shovels.

c. Post Digger.

d. Tamper.

e. Object Positioning Template (with centering laser and azimuth rose).

f. Dip Protractor.

g. Depth Measuring T.

h. Compass.

3. TARGET EMPLACEMENT. Below is a step by step procedure for all munitions/targets to be buried.

a. If the site has existing vegetation remove the layer of sod intact so it can be used to cover the disturbed area.

b. For each item to be buried note the desired burial depth and orientation of the object in accordance with the Calibration Lanes and Blind Test Grid layout and dig the hole to this depth using the two-man auger (fig. K-1) and hand shovels as appropriate. Use the depth measuring T for depth measurements.

Note: Since object depth measurements are recorded from the top most point of the object to the ground surface, the hole may have to be dug deeper than the desired depth to accommodate object orientation. Soils excavated when using the auger will be collected on a tarp and used later to backfill in the hole.

c. Place the object into the dug hole at roughly the desired orientation. The bottom of the hole should be prepared to allow the object to be positioned at the desired inclination by cutting the dirt out at the bottom at the appropriate angle. If additional dirt is needed to prop up the object, this dirt shall be compacted sufficiently so as to prevent the object from shifting when it is buried.

d. Place the object positioning template over the four grid square markers and level using the two integral leveling devices (fig. K-2). Turn on the integral centering laser and position the object so that the laser dot is at the geometric center of the object. At the same time, adjust the azimuth of the object as necessary to achieve the desired azimuth in accordance with the Calibration Lanes and Blind Test Grid layout.

Figure K-1. Example of a two-man auger.

Figure K-2. Example of object leveling using object positioning template and integral leveling devices.

e. With the object positioned as desired, and the object positioning template still installed, record the object azimuth (as read off of the positioning template) onto the field target placement sheet (fig. 3-3, section 3).

f. Remove the object positioning template and measure the object dip using the inclination protractor (fig. K-3). Position the edge of the protractor on the long axis edge of the object and then orient the arm of the protractor vertical. Read the dip and record onto the field target placement sheet.

Figure K-3. Measuring object dip using an inclination protractor.

g. Using the depth measuring T, measure the depth of the object. Position the T arms on the surface of the ground and slide the measuring stick until it gently touches the top most portion of the object (fig. K-4). Read the depth in centimeters and record onto the field target placement sheet.

h. Ensure the field target placement sheet is completely filled in with the date of burial, grid location, depth, azimuth and dip and signature.

Figure K-4. Measuring object depth using the depth measuring T.

i. Back fill the object with the excavated dirt by carefully filling around the object with fine dirt; taking care that the object does not shift position. Tamp in around the object as the hole is filled. Mound the dirt hole at the top surface (fig. K-5). Place the sod on top of the pile and water. Compact the area down gently and water the grass.

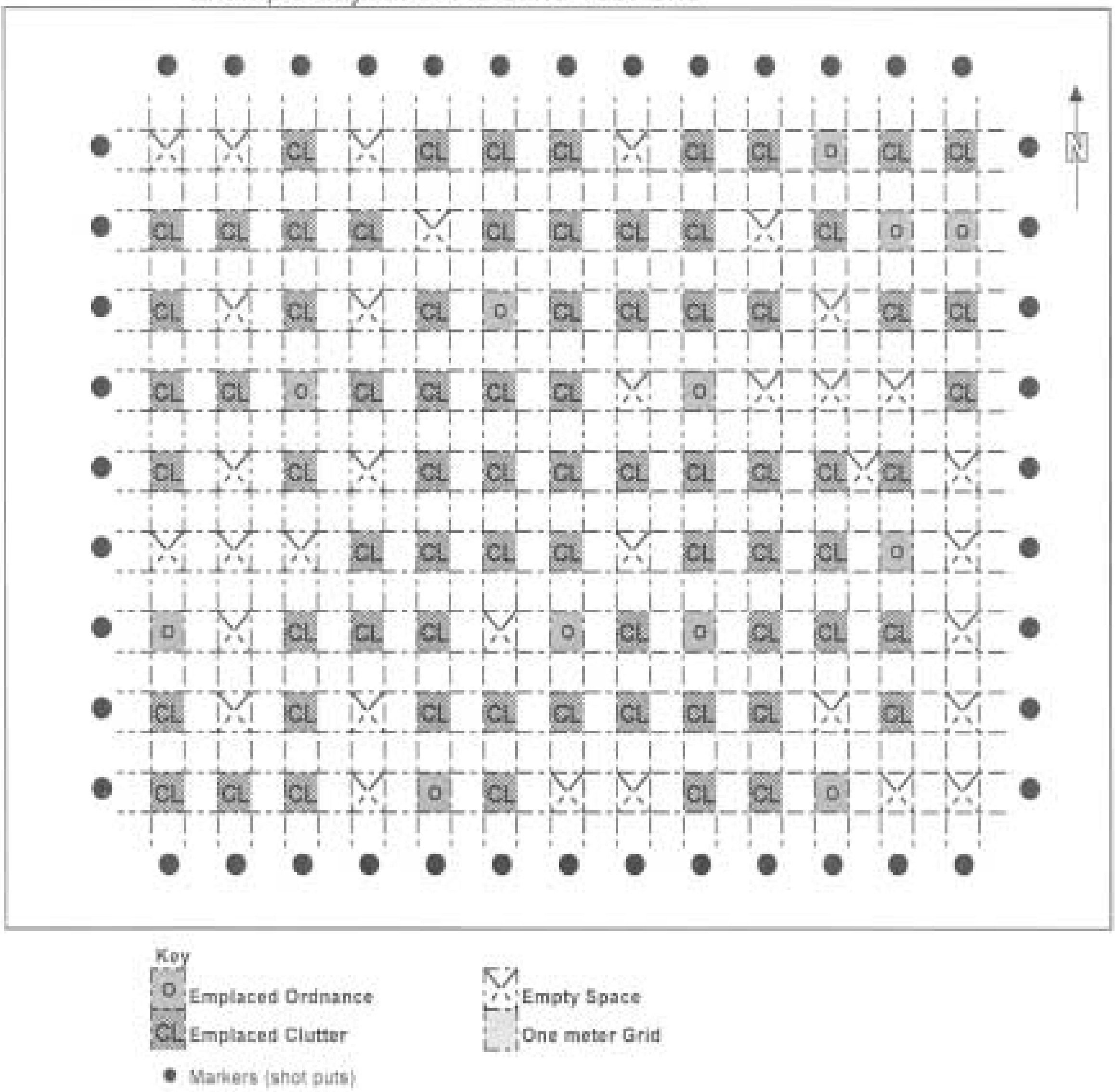
Figure K-5. Tamping down back fill after object burial.

j.   Repeat steps a through j for all grid squares.

k. Several weeks after emplacement check for depressions. If necessary, level with soil from the area.

APPENDIX L. EXAMPLE LAYOUT OF A BLIND TEST GRID

Example Layout of the Blind Test Grid



APPENDIX M. MOGUL DESIGN

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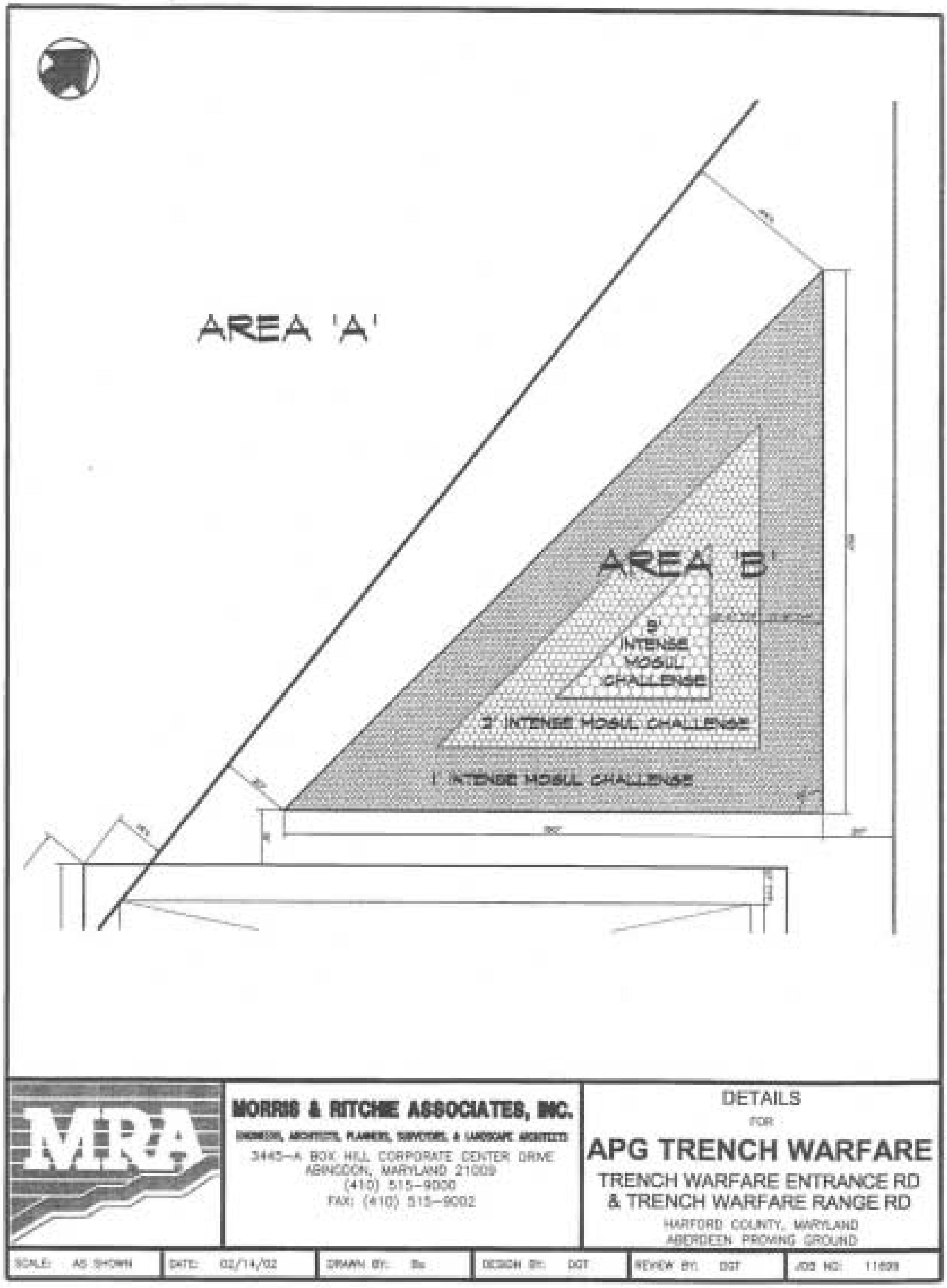
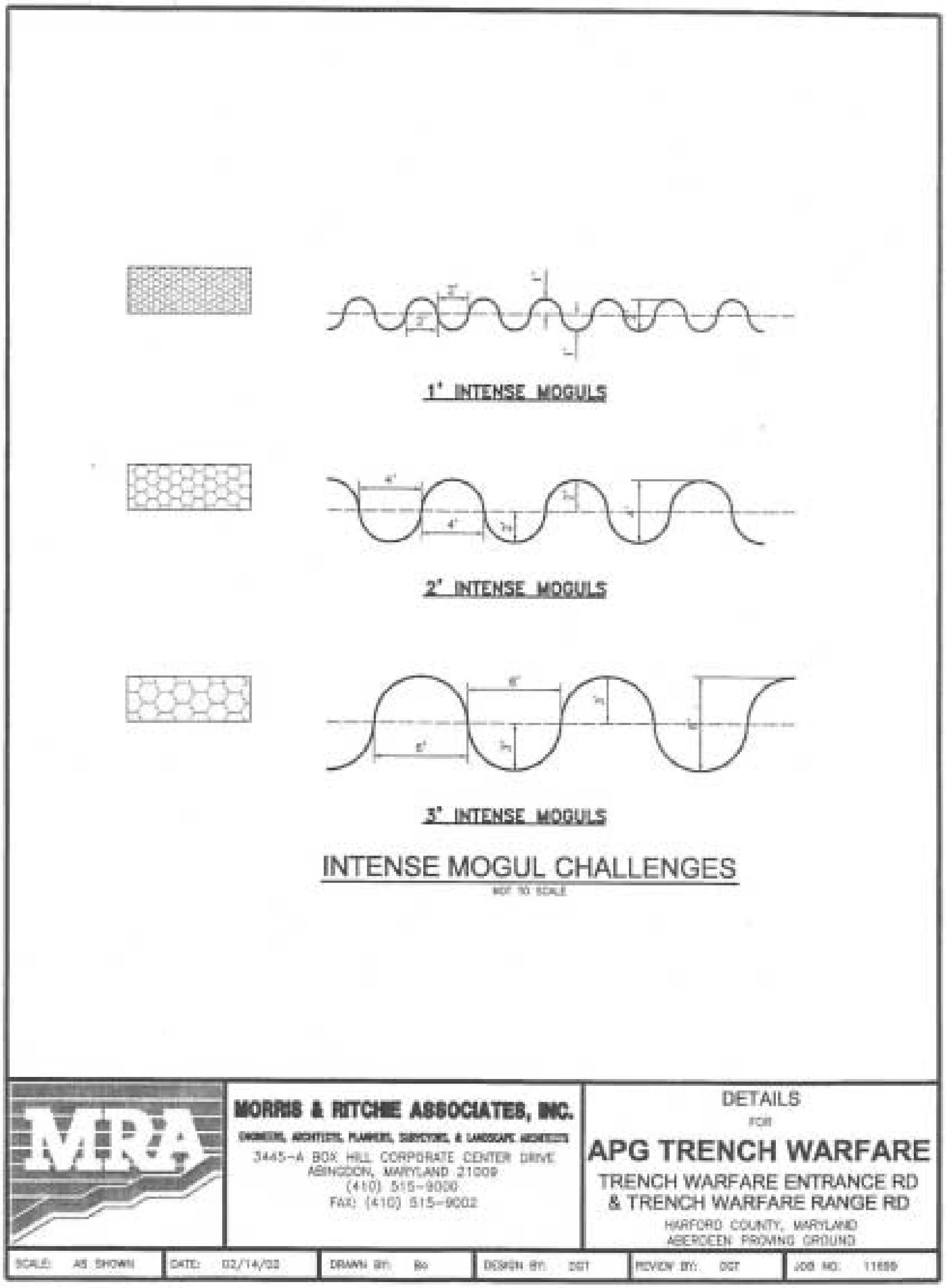
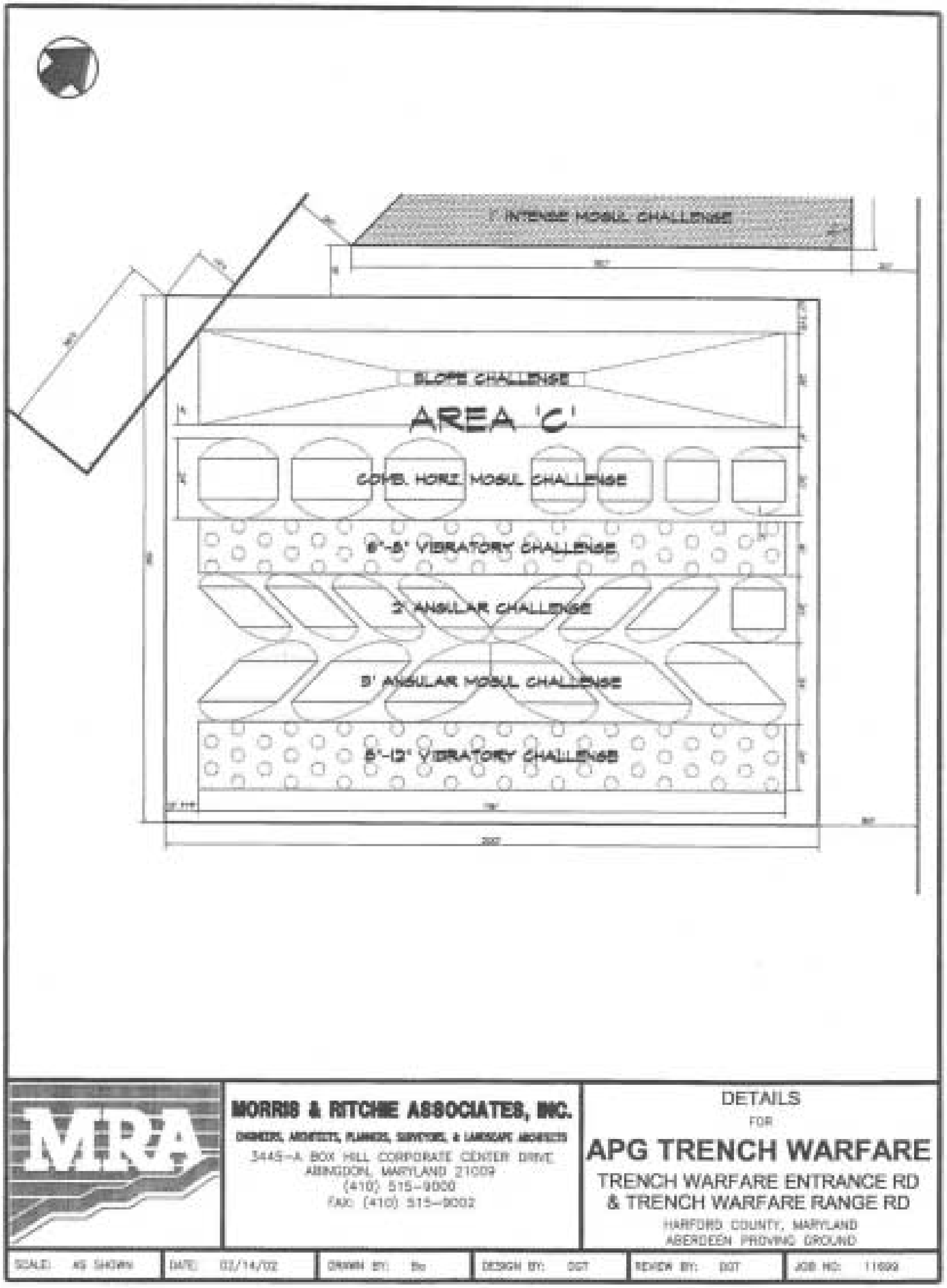
Intense Mogul Challenge



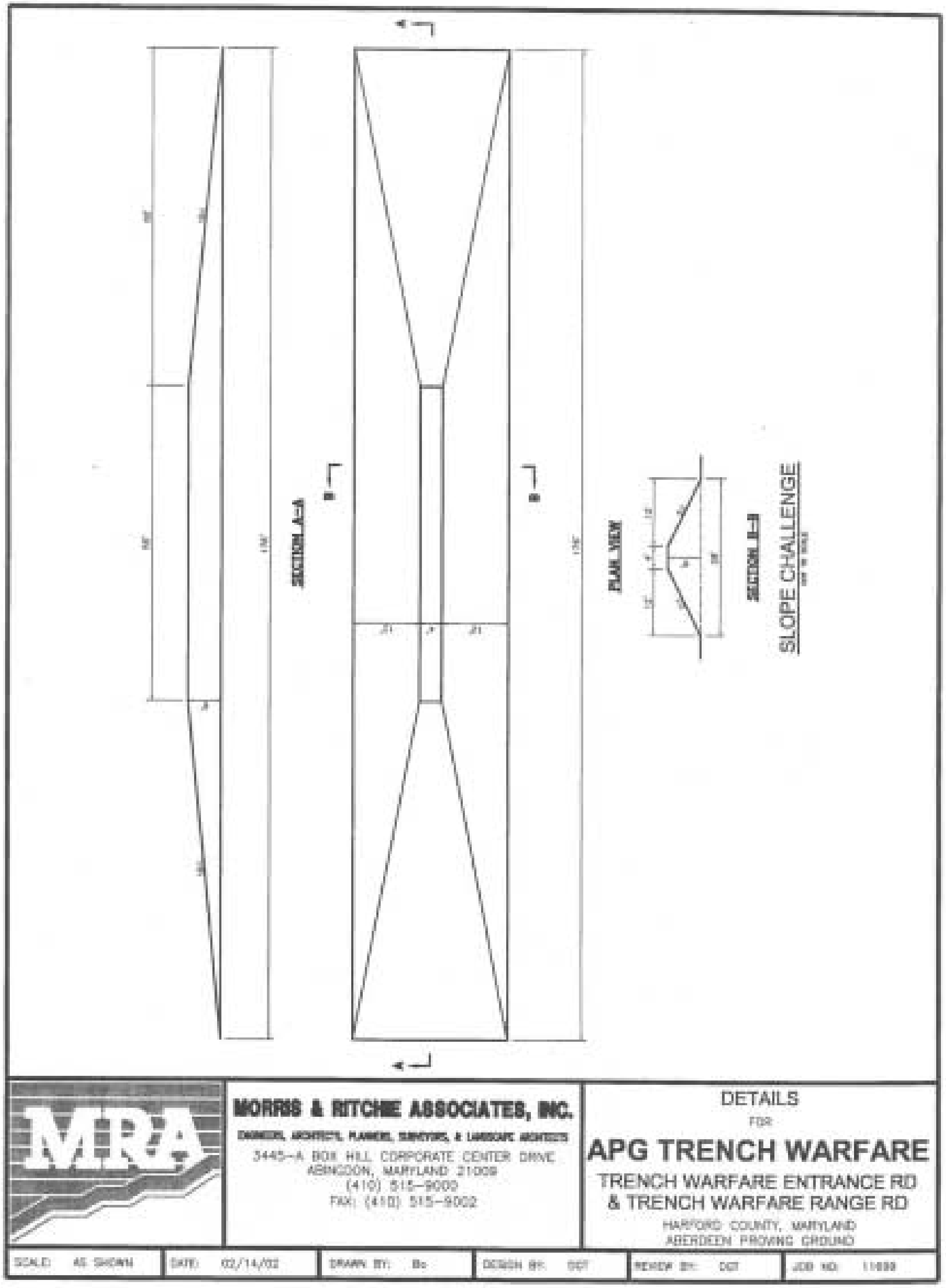
Intense Mogul Challenge



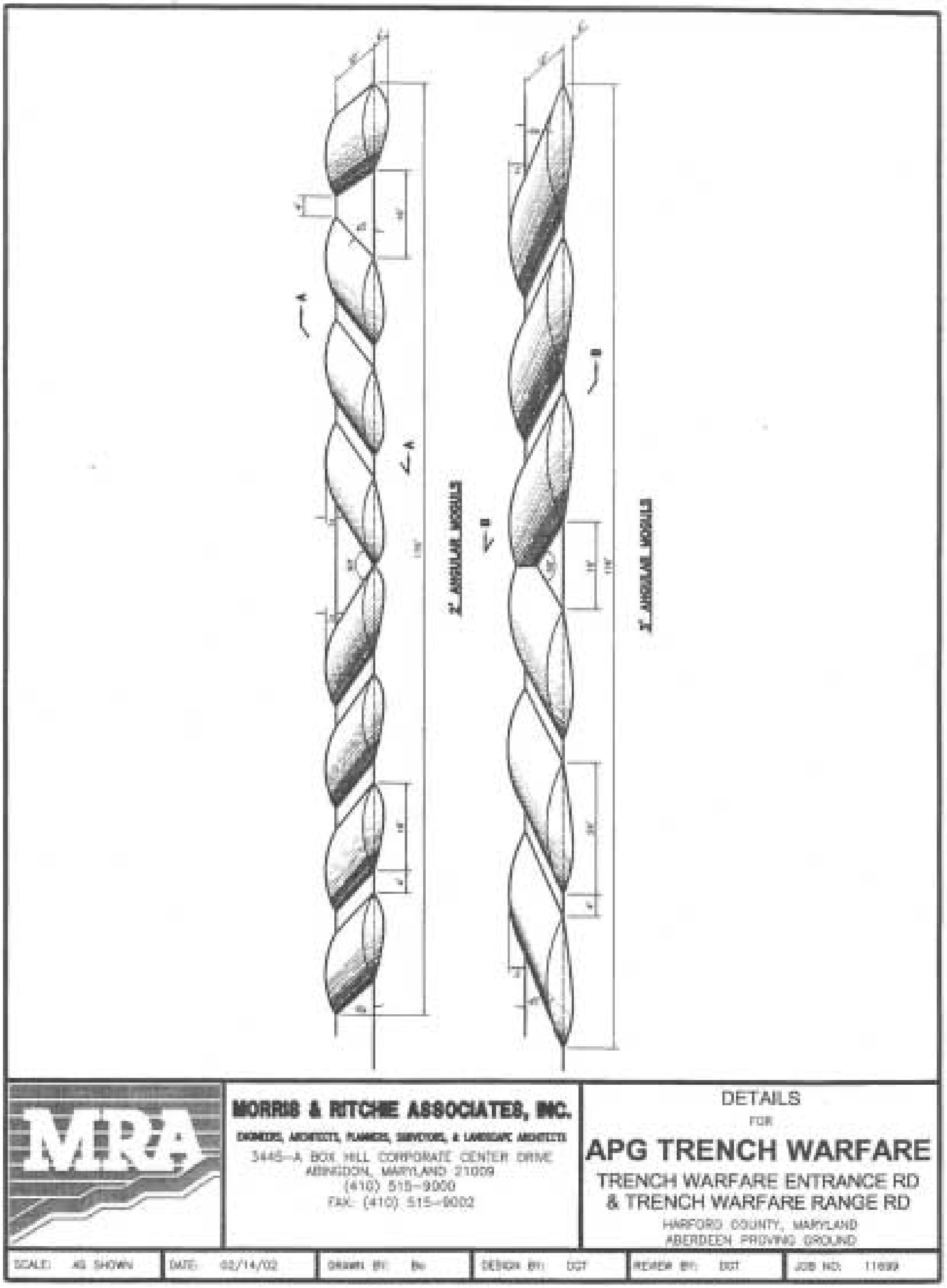
Mogul Challenge



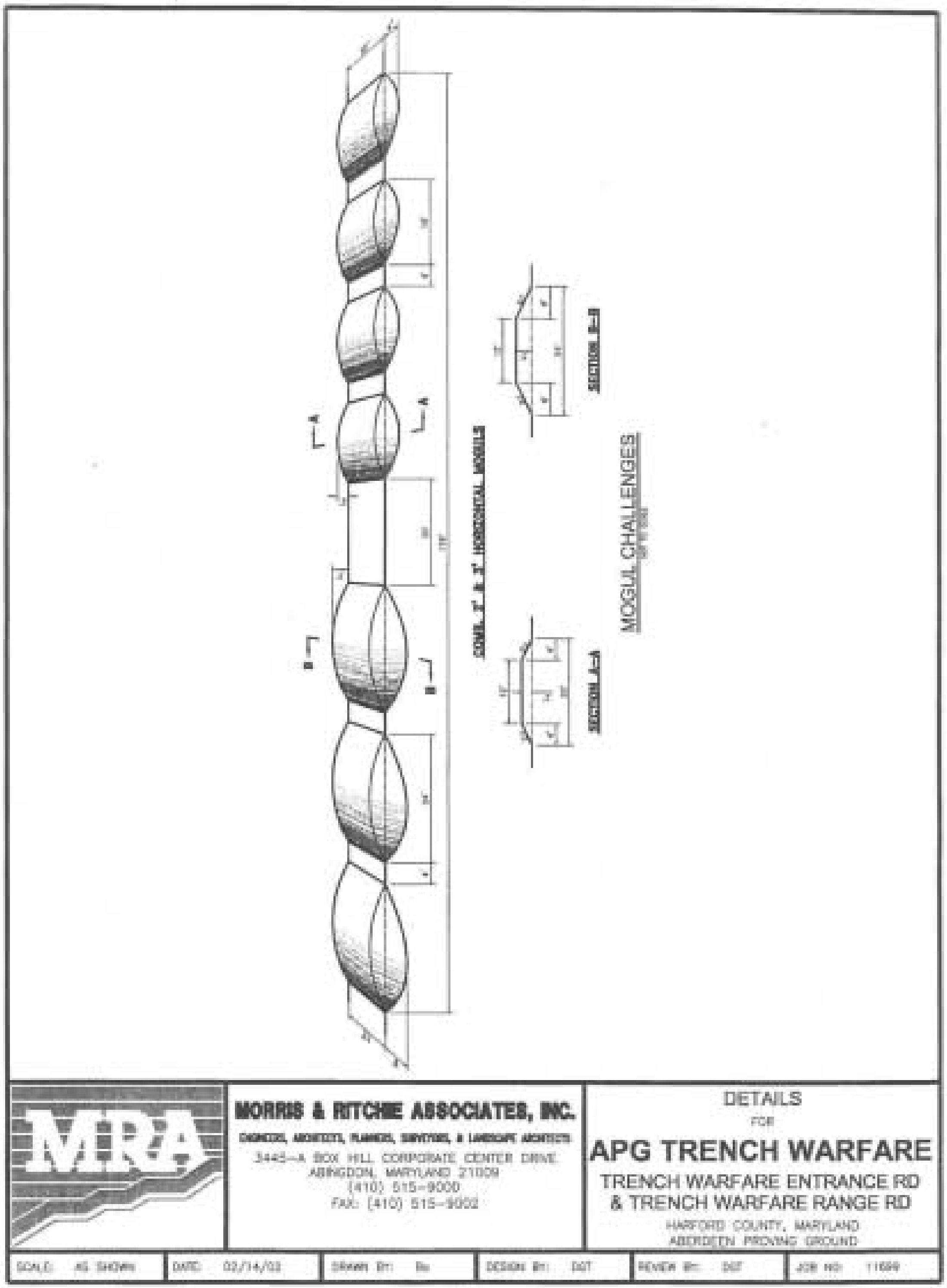
Mogul Slope Challenge



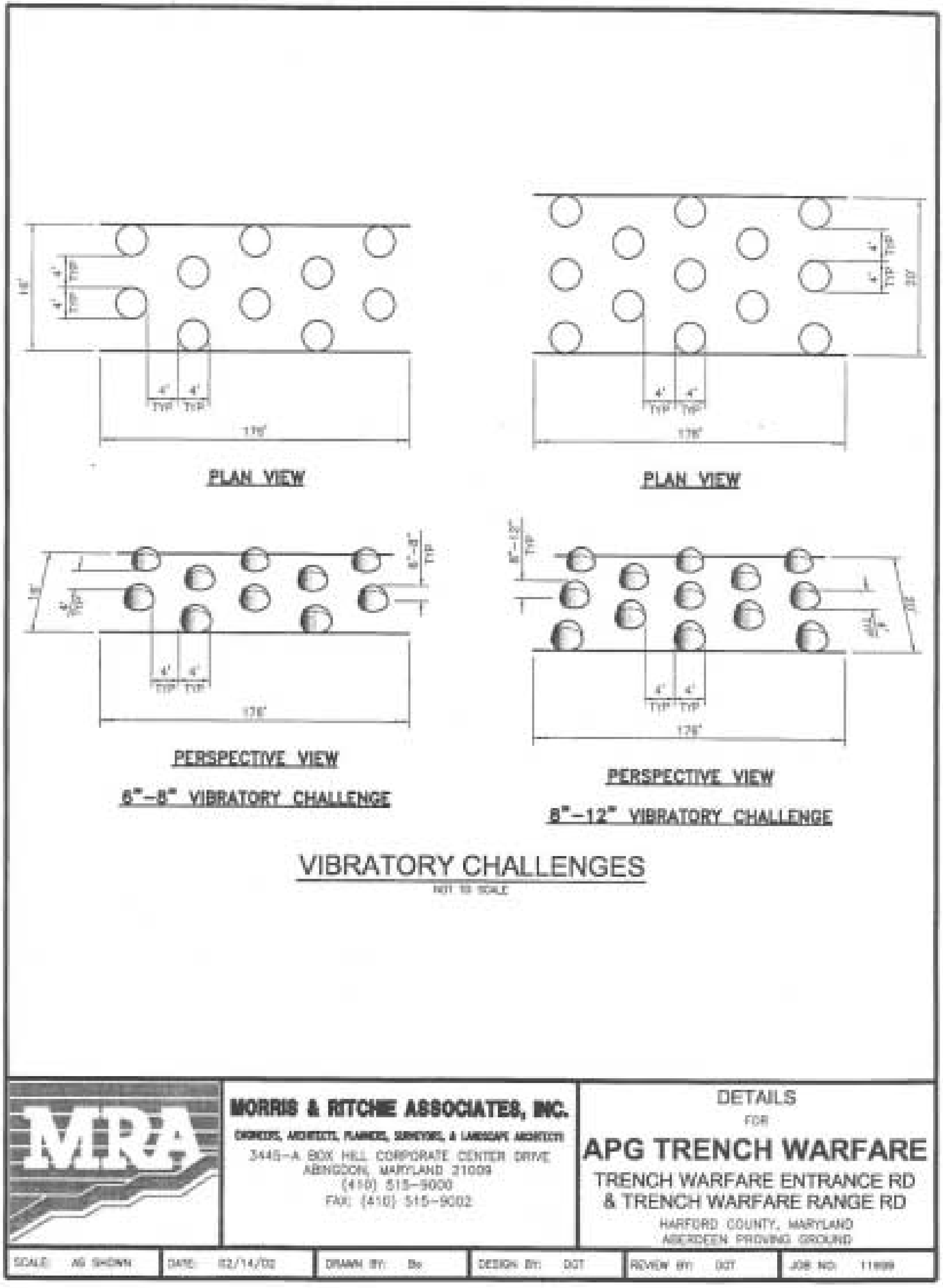
Angular Mogul Challenge



Straight Mogul Challenge



Mogul Vibratory Challenge



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APPENDIX N. TARGET EMPLACEMENT (DRILL AND PUSH RIG)

1. PURPOSE. The purpose of using the directional drilling/push rig is to replicate UXO penetration into the soil and also to prevent soil disturbance directly above the buried targets.

2. EQUIPMENT USED. Simco Earthprobe 200 directional drilling/push rig (fig. N-1) or equivalent.

Figure N-1. Simco Earthprobe 200.

The Simco Earthprobe 200 incorporates a variety of auger sizes, coring devices, and a pneumatic hammer, all which can operate at various angles on an articulated arm. The drilling equipment is mounted on an articulated, all-wheel-drive off road buggy.

3. DRILLING LOCATION DETERMINATION. Using the diagram shown in Figure N-2 and the following formulas, the values needed to determine the new (x,y,z) of the projectile entry point and the length of the boring hole can be generated.

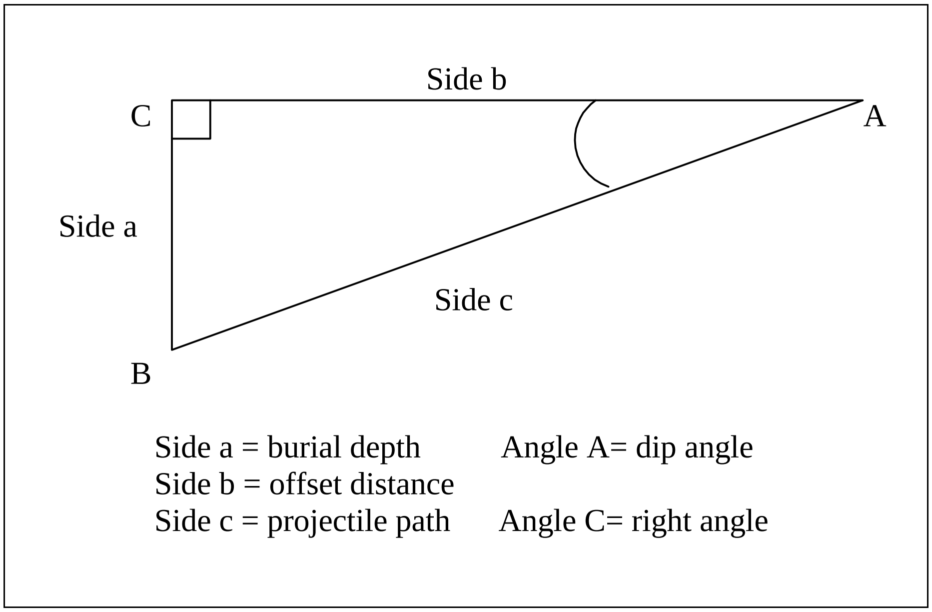

Figure N-2. Drilling location diagram.

To determine the drilling location, using the predetermined (x,y,z) UXO position, the burial depth, the dip (depression) angle, and basic trigonometric relationships.

a. Assuming angle C is a right angle, and using the burial depth as the length of side a and the dip angle as angle A, the sides b and c can be calculated.

b. Using side b and the azimuth or magnetic angle given for the placement of the UXO, the drilling grid position can be calculated using the GIS.

c. Using side c and the length of the UXO to be emplaced, the drilling length can be calculated.

Given burial depth, a, and drilling ∠A, the offset distance, b, can be calculated as; $\tan A = a/b$. $b \tan A = a$. $b = a/\tan A$.
Given burial depth, a, and drilling ∠A, and the computed value of the offset distance, b, the length of the projectile path, c, can be calculated as; $c^2 = a^2 + b^2$. $c = \sqrt{(a^2 + b^2)}$.

The drilling position can be calculated using the (x,y,z) position of the UXO, the UXO magnetic azimuth back-angle and the offset distance.

The drilling length is the length of the projectile path, c, plus the length of the UXO.

4. TARGET EMPLACEMENT (GENERAL). At the start of the site preparation activities for drilling, surveyors will locate and flag each of the target and drilling locations. When operating in a UXO contaminated area, a UXO clearance team, prior to drilling operations, will then clear each location. Vertical drilling by a Simco Earthprobe 200 is shown in Figure N-3.

Figure N-3. Vertical drilling by Simco Earthprobe 200.

5. DRILLING PROCEDURE. Drilling will commence in the following manner:

a. Using the field target placement sheet (fig. 3-3, section 3) and RTK-GPS, place flags at both the target location and drilling location, using (x,y,z) coordinates.

b. Using the boom on the drill rig as a guide, place the drill rig behind the drilling flag, with the drill point pointing toward the target flag, as shown in Figure N-4.

Figure N-4. Positioning the drill rig.

c. Tilt the drilling boom to the desired dip angle, read dip angle on angle gauge attached to the Simco boom as demonstrated in Figure N-5.

Figure N-5. Positioning the drilling boom.

d. Determine if additional extensions are required for the drill rig boom to contact the ground surface at the desired drilling angle. Figure N-5 shows the Simco rig with one extension preparing to drill a hole at 30°.

e. Determine the correct size (diameter) of the auger bit to be used given the diameter of the UXO.

Note: The drill diameter should always be larger than the UXO, and when emplacing a 155-mm or larger UXO, a smaller diameter 2- by 4-inch pilot hole should be drilled first, followed by the proper diameter hole.

f. Dig a shallow hole to remove the grass sod (reserve on plastic so it can be replaced) and extend drill bit so drill point will contact soil.

g. Recheck desired dip angle.

h. Recheck the distance from drill point entry and target location and compare to calculated length b on emplacement sheet.

i. Standing behind the target flag, recheck drilling azimuth angle prior to drilling.

j. Using a paint pen, mark drill sections in metric units so drill hole depth can be determined while drilling.

k. Start the drilling procedure, removing soil with a shovel from around the drill hole and place it on plastic for reuse in packing soil back in the hole. An example of angle drilling is shown in Figure N-5.

l. After maximum drilling depth is achieved, slowly remove drill stem sections and soil from drill hole to prevent soil from back filling hole.

m. Using a long aluminum conduit, recheck calculated drilling depth by placing conduit in hole to maximum depth. Measure actual drilling length and record on the field target placement sheet (fig. 3-3, section 3).

n. With conduit touching the bottom edge of drill hole, place an angle gauge parallel to the conduit at the point where the conduit exits the ground. Measure the reading and record that information on the field target placement sheet.

o. Compare calculated versus actual; if adjustments are necessary, reconstruct drilling procedure from step g above until correct.

p. Place UXO in required orientation (nose up (+) or down (-)) and push into place with heavy pipe or conduit. If resistance is encountered, push UXO into desired position with pneumatic hammer and drill pipe on drill rig until desired position is achieved (fig. N-6).

Note: Water may be added to clay soils to assist this procedure.

Figure N-6. UXO placement for burial.

q. Remove drill pipe from hole, recheck depth of UXO using procedure m above and, if correct, or if there is no way to move UXO any deeper, begin placing soil back in hole using long aluminum conduit or pipe to assist pushing soil down hole. Use pipe or long 2 by 4 to tamp soil down in the hole in no greater than 1-meter segments.

r. Replace sod at drill entry point and remove any excess soil to an off-site spot.

s. Ensure the field target placement sheet is completely filled in with date of burial, location, depth, azimuth and dip, and signature.

t. Move rig to next point.

6. POST EMPLACEMENT SURVEY. Using the measurements taken in step 5m, there should be no requirement for a post emplacement survey. If the distance or angle measured is different from the plan, then a recalculation adjustment may be necessary. Any post emplacement real-time kinematic (RTK)-GPS survey would require assistance from an EM, Magnetic, or GPR to locate the buried object for the surveyor.

APPENDIX O. SITE APPLICATION PROCESS AND FORMS

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HOW TO APPLY TO USE THE STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITES

INITAL REQUEST

The initial request is designed to start a dialog between the demonstrator and Standardized UXO Technology Demonstration Site Project Manager. This initial request should be submitted in the form of the Standardized UXO Technology Demonstration Site Application. This application should be submitted 60 days in advance.

ATC and AEC will review the request package when it is received. Once approved, the demonstrator and on-site Project Manager will schedule the demonstration.

THIRTY DAYS IN ADVANCE/SITE USAGE REQUIREMENTS

Thirty days prior to arriving on-site, the demonstrator is responsible for supplying the Standardized UXO Technology Demonstration Site Project Manager three items: a Demonstration Test Plan, a Quality Assurance/Quality Control (QA/QC) Plan, and a Site Safety and Health Plan.

DEMONSTRATION TEST PLAN - The test plan is a detailed description of detection/sensor equipment, summary of how data are collected, analyzed, and the decision process by which algorithm discriminates between ordnance and munitions. The test plan should describe objectives and planned use of the Calibration Lanes/Ground Test Pit, Blind Test Grid, and Open Field Sites. The Calibration Lanes must be completed first, followed by the Blind Test Grid, and last the Open Field Site. No partial scoring is permitted.

QA/QC PLAN - The QA/QC Plan is a description of the demonstrator's QA/QC procedures. The QC portion is the description of how systems checks are performed by the demonstrator to check on items such as tracking, accuracy, drift, and system performance. The QA portion is the description of the procedures to be employed during the demonstration to include items such as lane spacing, sampling rates, and estimated accuracy of navigation and tracking systems.

SITE SAFETY AND HEALTH PLAN - The Site Safety And Health Plan is intended to be an all inclusive listing of potential site safety and health concerns that should be considered as part of each demonstration. An outline of a suggested Site Specific Safety and Health Plan is provided but demonstrators must tailor the plan to their specific technologies concerns. Some sections within the suggested plan will therefore not be applicable to all demonstrators but serves as a template to address their specific actions while working at the site.

APPLICATION FOR THE STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE

Demonstrator Name:

Technology Name:

Demonstrator Address:

Demonstrator Main Phone number:

Demonstrator Main Fax number:

Demonstrator Main email address:

Point of Contact (POC):

POC Phone number:

POC Fax number:

POC e-mail address:

Site location: APG, YPG, Camp Edwards (MMR)

Areas To Be Utilized: Calibration Lanes, Blind Grid, Open Field.

Number of Days Site is Required:

Dates requested:

Prior Visits:

System Description (limit one page):

System Picture:

Data Process Description (limit one page):

Overview of Quality Control (QC):

Overview of Quality Assurance (QA):

Demonstrator’s Field Personnel:

Support Equipment Required:

Frequency and Radio Utilization:

EXPLANATION FOR THE APPLICATION FOR THE STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE

Application Should Be Filled In Times New Roman Size 12 Font
Information Provided in this Application Will Be Used To Fill Data Points in the Final Report

Demonstrator Name: Name of Company or Organization Running Demonstration

Technology Name: Name of Technology To Be Demonstrated

Demonstrator Address: Full Mailing Address of the Demonstrator

Demonstrator Main Phone Number: Phone number of the Demonstrator

Demonstrator Main Fax Number: Fax number of the Demonstrator

Demonstrator Main E-mail Address: Email address of the Demonstrator

POC: Lead POC for the Demonstration

POC Phone Number: Phone number of the Lead POC

POC Fax Number: Fax number of the Lead POC

POC E-mail Address: Email address of the Lead POC

Site location: APG, YPG, Camp Edwards (MMR) which standardized site is this application addressing

Areas To Be Utilized: Calibration Lanes, Blind Grid, Open Field. What areas is data to be collected from. Note that all demonstrators must utilize the Calibration Lanes before going to the blind grid. All demonstrators must utilize the Calibration Lanes and Blind Grid before going to the Open Field.

Number of Days Site is Required: How many working days will the demonstrator be on site. This includes mobilization, demobilization, and actual demonstration.

Dates Requested: What are the dates that the demonstrator would like to utilize the site.

Prior Visits: List previous demonstrations utilizing the technology at any of the standardized sites. Include final report numbers from the demonstration.

System Description (limit one page): This description should include information on the type of instrument (physics, characteristics, dimensions, etc.), specifications for transmit pulses, bandwidths, instrument settings (gains, etc.), description of preprocessing methods (averaging,

background subtraction, etc.), measurement units, instrument height, orientation, equipment safety hazards and physical characteristics.

System Picture: Paste a picture of the technology to be tested.

Data Process Description (limit one page): This section will detail the process by which data are collected by the demonstrator. This can include spatial sampling rate, frequency and/or time sampling rate, raw data output format (ASCII, binary), data format, etc. (one page limit).

Overview of Quality Control (QC): This section is an overview of the complete QC portion of the QA/QC Plan. The QC portion is the description of how systems checks are done by the demonstrator to check on items such as tracking, accuracy, drift, and system performance.

Overview of Quality Assurance (QA): This section is an overview of the complete QA portion of the Quality Assurance/Quality Control (QA/QC Plan). The QA portion is the description of the procedures to be employed during the demonstration to include items such as lane spacing, sampling rates, and estimated accuracy of navigation and tracking systems.

Demonstrator's Field Personnel: The Site Personnel list will contain the names of people the demonstrator is planning to bring on-site. Each individual role and responsibility during the demonstration must be described. Note: Each individual needing access to the site will be required to provide information such as social security and driver licenses numbers to gain access to the military installation. Foreign nationals will need to submit a site visit request through their respective embassies. Access to the standardized site will be coordinated with the individual site manager.

Support Equipment Required: List all equipment, vehicles, and expendables to be brought onto the site by the demonstrator. Storage needs for these items should also be identified. List any logistics, support equipment, or special needs that the demonstrator will request from the site manager.

Frequency and Radio Utilization: In this section, provide a listing of frequencies and power of EM/FM and radio (including DGPS) equipment to be utilized at the site. This information is used to coordinate and determine RF interference to or from the host installation.

SUBMISSION OF DATA FOR SCORING

The demonstrator is responsible for submitting two sets of data for each area within the standardized test site. The sets of data required are Raw Sensor Data and Processed Sensor Data.

RAW SENSOR DATA

Raw sensor data are sensor specific, rudimentary forms of data with the corrected GPS diurnal variations applied by the sensor system prior to being subjected to post processing algorithms (i.e., raw data for a magnetometry system would be the magnetic flux readings in nano-Tesla relative to time and position).

PROCESSED SENSOR DATA

Processed sensor data are the result of the demonstrator's manipulation of the raw data collected by their sensor. The processed data is the equivalent to a dig sheet. This program requires that there be two stages of processed data submitted, response stage and discrimination stage. The demonstrator will be scored based on the information provided in the processed sensor data.

The demonstrator must submit the following data for each test area visited:

a. Calibration Lanes.

(1) Raw sensor data prior to leaving the site.

(2) No processed data required.

b. Blind Test Grid.

(1) Raw sensor data prior to leaving the site.

(2) Processed data within 30 days of leaving the site.

c. Open Field and open field scenarios.

(1) Raw sensor data prior to leaving the site.

(3) Processed data within 30 days of leaving the site.

RAW DATA SUBMITTAL

All demonstrators must submit raw sensor data for each area scanned to the on-site Project Manager before leaving that site. The raw sensor data shall be provided electronically on a digital storage media (i.e., CD, floppy disk, JAZ, Zip, etc.) in ASCII format. Deviations from using ASCII format must be coordinated 30 days in advance of entering the test site.

PROCESSED DATA SUBMITTAL

Demonstrators must submit processed test data within 30 days after test completion. These data are given to the on site program manager and consist of response sensor output and algorithm results data in the government provided electronic Excel spreadsheet. It is important to note that the time to submit the processed data will be reported in the final report. Examples of the spreadsheets can be found in Tables O-1 and Table O-2.

TABLE O-1. SAMPLE PROCESS DATA SPREADSHEET FOR BLIND TEST GRID

	Letter	Number	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Az, deg	Dip, deg
1	A	1	0.849	8	C	-	-	-	-
2	A	2	2.852	29	O	20-mm	1.72	142	-69.40
3	A	3	8.209	86	O	105-mm	0.86	16	-52.10
4	B	1	-	-	B	-	-	-	-
5	B	2	9.980	101	O	BDU28	0.37	140	40.16
6	B	3	12.679	3	C	-	-	-	-

TABLE O-2. SAMPLE PROCESS DATA SPREADSHEET FOR OPEN FIELD

	Northing	Easting	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Az, deg	Dip, deg
1	14335954.399	1322776.533	0.649	1	C	-	-	-	-
2	14335810.267	1322622.501	2.852	76	O	20-mm	1.72	142	-69.40
3	14335769.862	1322340.290	8.209	86	O	105-mm P	0.86	16	-52.10
4	14335723.867	1322372.153	1.757	20	C	-	-	-	-
5	14335667.910	1322381.300	0.491	30	C	-	-	-	-

Letter - Combined with Number provides grid location on the Blind Test Grid.

Number - Combined with Letter provides grid location on the Blind Test Grid.

Response Stage - Ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. The response stage provides the location and signal strength of all anomalies deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

Discrimination Stage - Ability to correctly identify ordnance as such, and to reject clutter for the same locations as in the response stage anomaly column. The discrimination stage column contains the output of the algorithms applied in the discrimination-stage processing. This

column is prioritized based on the determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that provides optimum system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Classification - Demonstrator determines if the item is ordnance (O), clutter (C) or blank (B).

Type - If a demonstrator determines an item is ordnance, provide the caliber. A demonstrator leaves this blank for clutter or an empty square.

Depth - Demonstrator identifies the depth to the top of the ordnance item.

Azimuth - Demonstrator provides the direction of the ordnance relative to magnetic north. The nose of the projectile facing magnetic north will indicate 0^{o} azimuth.

Dip - Demonstrator provides the incline of ordnance in degrees. To indicate ordnance in a nose down orientation a - will be used. To indicate ordnance in a nose up orientation a + will be used.

SITE SAFETY AND HEALTH PLAN

The following Table of Contents (TOC) is intended to be a general, all inclusive, listing of potential Site Safety and Health Concerns that should be considered as part of each demonstrator's Site Specific Safety and Health Plan. Some sections within this TOC will therefore not be applicable to some demonstrators (i.e., radiological sources, hazardous material shipping, etc.). Rather, each demonstrator should tailor the below listed TOC to address their specific actions while working at the site.

1.0 PURPOSE

2.0 APPLICABILITY

3.0 SITE SPECIFIC INFORMATION

3.1 GENERAL DESCRIPITION
3.2 SITE DESCRIPTION AND SUMMARY OF WORK
3.3 HAZARD ANALYSIS FOR SITE TASKS
3.3.1 Chemical Hazards
3.3.2 Physical Hazards
3.3.3 Fire and Explosion Hazards
3.3.4 Biological Hazards
3.3.5 Electrical Hazards
3.3.6 Heat/Cold Stress
3.3.7 Noise Hazards
3.3.8 Heavy Equipment
3.3.9 Underground and Overhead Utilities
3.3.10 Portable Hand and Power Tools
3.3.11 Fall Hazards/Working At Heights
3.3.12 Heavy Equipment
3.3.13 Excavations
3.3.14 Unexploded Ordnance
3.4 FIELD PERSONNEL
3.5 EMERGENCY INFORMATION
3.5.1 Emergency Contacts
3.5.2 Location of Site Resources
3.5.3 Hospital Route Information
3.5.4 Emergency Response Plan
3.5.5 Reporting of Accidents and Unsafe Conditions

4.0 SITE CONTROL

4.1 GENERAL
4.2 SITE WORK ZONES
4.3 STANDARD SAFE WORK PRACTICES
4.3.1 General
4.3.2 Buddy System

5.0 MONITORING
5.1 GENERAL
5.2 MONITORING REQUIREMENTS
5.2.1 Instrument Calibration

6.0 PERSONAL PROTECTIVE EQUIPMENT
6.1 GENERAL
6.2 LEVELS OF PROTECTION
6.3 PERSONAL PROTECTIVE EQUIPMENT PROGRAM

7.0 RADIOLOGICAL SOURCES
7.1 Radiological Worker Training
7.2 Permits

8.0 DECONTAMINATION
8.1 STANDARD PROCEDURES
8.2 DECONTAMINATION OF EQUIPMENT
8.2.1 Sampling Devices
8.2.2 Tools
8.2.3 Heavy Equipment
8.2.4 Sanitizing of Personal Protective Equipment
8.2.5 Persistent Contamination
8.2.6 Disposal of Contaminated Materials
8.3 MINIMAL DECONTAMINATION
8.4 CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

9.0 EMPLOYEE TRAINING ASSIGNMENTS
9.1 GENERAL
9.2 INITIAL TRAINING
9.3 MANAGEMENT AND SUPERVISOR TRAINING
9.4 REFRESHER TRAINING
9.5 ADDITIONAL TRAINING REQUIREMENTS

10.0 MEDICAL SURVEILLANCE
10.1 GENERAL
10.2 FREQUENCY OF MEDICAL EXAMS
10.3 MEDICAL SURVEILLANCE RECORDS

11.0 STANDARD OPERATING PROCEDURES
11.1 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES
11.1.1 Project Manager
11.1.2 Project Safety and Health Manager
11.1.3 Site Safety and Health Officer
11.1.4 Project Site Personnel
11.1.5 Subcontractor’s Safety Representative
11.2 HEAT STRESS/COLD STRESS
11.4 ELECTRICAL SAFETY/LOCKOUT AND TAGOUT

11.5 UNDERGROUND AND OVERHEAD UTILITIES
11.6 PORTABLE HAND AND POWER TOOLS
11.7 FALL PROTECTION PROCEDURES
11.8 EXCAVATIONS

12.0 HAZARD COMMUNICATION
12.1 GENERAL
12.2 COMPLIANCE REQUIREMENTS

13.0 POSTING OF NOTICE

14.0 TOXIC SNAKE AND OTHER BITES AND PLANTS
14.1 POISONOUS SNAKEBITES
14.2 OTHER POISONOUS BITES
14.2.1 Spiders
14.2.2 General First Aid for Poisonous Insect Bites
14.4 TICKBORNE DISEASES
14.4.1 Lyme Disease
14.4.2 Rocky Mountain Spotted Fever
14.4.3 Other Tickborne Diseases
14.5 POISONOUS PLANTS
14.5.1 Characteristic Reactions
14.5.2 First Aid Procedure

15.0 ACCIDENT PREVENTION PLAN
15.1 RESPONSIBILITIES
15.2 RECORDKEEPING AND INCIDENT REPORTING
15.2.1 Program Responsibilities
15.2.2 Accident and Illness Investigation
15.2.3 Responsibilities For An Accident or Illness Investigation
15.2.4 Incident/Accident Reporting
15.2.5 Recordkeeping
15.3 DAILY WORK AREA INSPECTIONS

16.0 SPILL CONTROL
16.1 NOTIFICATION OF SPILLS AND DISCHARGES
16.2 REQUIRED EQUIPMENT
16.3 SPILL CONTROL
16.4 DECONTAMINATION

17.0 HAZARDOUS MATERIALS SHIPPING
17.1 BASIC REQUIREMENTS
17.2 SHIPPING IDENTIFIED HAZARDOUS MATERIALS
17.3 SHIPPING SAMPLES

18.0 FORMS

19.0 MATERIAL SAFETY DATA SHEETS

20.0 ATTACHMENTS

APPENDIX P. SCORING

SCORING

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1. Scoring Objectives

a. The objective of the Standardized UXO Technology Demonstration Site Program is to evaluate UXO detection and discrimination capabilities under various field and soil conditions. Technologies are evaluated on highly controlled sites with inert munitions and clutter items positioned in various orientations and depths in the ground. After visiting a standardized site, demonstrators will be evaluated based on survey results and field operations.

b. The evaluation criteria are as follows:

(1) Detection and discrimination under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

(2) Cost, time, and manpower requirements.

(3) Ability to analyze survey data in a timely manner and provide prioritized target lists with associated confidence levels.

(4) Collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

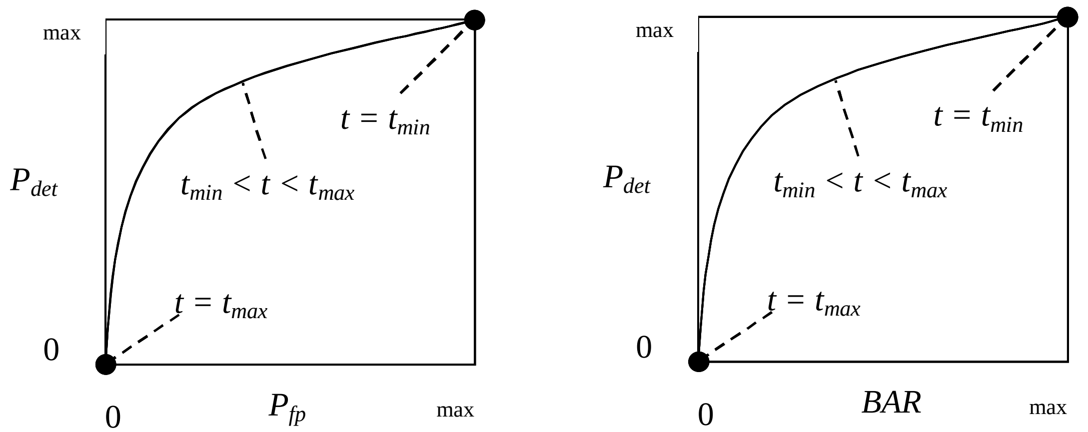
2. Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE.

(1) The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the field location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

(2) The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the same field locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator selects the threshold that is believed to provide optimum system performance (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

b. For both stages, the probability of detection (P_{det}) and the false alarms are reported as receiver-operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms (BA). The ROC curves P_{det} versus P_{fp} and P_{det} versus background alarm rate (BAR), as the threshold applied to the signal strength, is varied from its minimum (t_{min}) to its maximum (t_{max}) value. Figure P-1 shows how P_{det}, P_{fp}, and BAR are combined into ROC curves.[1]



Each curve will be calculated for both the response and discrimination stages.

Figure P-1. ROC Curves.

c. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the amount of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

[1] Strictly speaking, ROC curves plot the P_{det} versus P_{fp} over a predetermined and fixed number of detection opportunities (some of the opportunities are located over targets and others of are located over clutter or blank spots). In an open-field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open-field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Test Grid sites are true ROC curves.

3. Scoring of the Data

3.1 Blind Test Grid

a. The Blind Test Grid is designed to test detection systems and algorithms without considering location accuracy or platform effects. The demonstrator is given 400 grid locations (opportunities) to investigate. When the demonstrator investigates opportunities, the following questions must be answered:

(1) What is the signal level in each grid location? (Note: Analog or human judgment requires 1 or 0 indicating either a detection or an empty grid, respectively.)

(2) If the sensor has the ability to discriminate:

(a) What is the numerical result of the discrimination algorithm (electronic, human or some combination) to reflect whether grid location contains ordnance, clutter, or is empty?

(b) If it is ordnance:

1 What is it? (For example: 155-mm projectile, 2.75-inch rocket or BLU-26 submunition.)

2 What is its depth?

3 What is its orientation? (This information is not scored.)

a Azimuth - horizontal rotation relative to magnetic North (0 to 360^{o}).

b Dip - vertical orientation relative to the horizontal plane (0 $\pm$ 90^{o}).

b. The data collected by the demonstrator are processed and submitted to the scoring committee in the required format. A computer program compares the demonstrator data to the ground truth database. The program links the grid location in the ground truth database to the demonstrator's data.

3.1.1 Blind Grid Scoring Example.

Table P-1 is an example of the demonstrator's data in the required format. Table P-2 is an example of hypothetical ground truth data. Table P-3 is an example of the computer program linking the grid locations.

TABLE P-1. DEMONSTRATOR DATA FOR BLIND TEST GRID

	Grid Letter	Grid No.	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	A	1	0.649	2	C	-	-	-	-
2	A	2	2.852	5	O	20-mm	1.72	142	-69
3	A	3	8.209	33	O	105-mm	0.86	16	-52
4	B	1	1.757	9	C	-	-	-	-
5	B	2	0.491	0	B	-	-	-	-
6	B	3	9.980	52	O	155-mm	0.37	140	40
7	C	1	12.679	8	O	105-mm	0.28	137	70
8	C	2	0.649	7	C	-	-	-	-
9	C	3	2.852	14	O	BLU26	0.72	122	55

O = Ordnance.
C = Clutter.
B = Blank.

TABLE P-2. HYPOTHETICAL GROUND TRUTH DATA

	Grid Letter	Grid No.	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	A	1	C	-	-	-	-
2	A	2	O	20-mm	2.00	175	-80
3	A	3	O	105-mm	0.86	23	-40
4	B	1	B	-	-	-	-
5	B	2	B	-	-	-	-
6	B	3	O	105-mm	0.37	145	50
7	C	1	C	-	-	-	-
8	C	2	C	-	-	-	-
9	C	3	O	M42	1.00	135	45

O = Ordnance.
C = Clutter.
B = Blank.

TABLE P-3. COMPUTER PROGRAM LINKING GRID LOCATIONS

	Grid Letter	Grid No.	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	A	1	0.649	2	C	-	-	-	-
(gt)	A	1	-	-	C	-	-	-	-
2	A	2	2.852	5	O	20-mm	1.72	142	-69
(gt)	A	2	-	-	O	20-mm	2.00	175	-80
3	A	3	8.209	33	O	105-mm	0.86	16	-52
(gt)	A	3	-	-	O	105-mm	0.86	23	-40
4	B	1	1.757	9	C	-	-	-	-
(gt)	B	1	-	-	B	-	-	-	-
5	B	2	0.491	0	B	-	-	-	-
(gt)	B	2	-	-	B	-	-	-	-
6	B	3	9.980	52	O	155-mm	0.37	140	40
(gt)	B	3	-	-	O	105-mm	0.37	145	50
7	C	1	12.679	8	O	105-mm	0.28	137	70
(gt)	C	1	-	-	C	-	-	-	-
8	C	2	0.649	7	C	-	-	-	-
(gt)	C	2	-	-	C	-	-	-	-
9	C	3	2.852	14	O	BLU26	0.72	122	55
(gt)	C	3	-	-	O	M42	1.00	135	45

C = Clutter.
B = Blank.
Gt = Ground truth.
O = Ordnance.

3.1.2 Development of ROC Curves - Response Stage

a. In the response stage, the computer algorithm scores the demonstrator's data by grid location, comparing the response column to ground truth data. After linking the demonstrator data to the ground truth database, the program thresholds the demonstrator response data. The threshold increment is determined by dividing the range (maximum - minimum) of response stage values into a desired number of increments. Table P-4 shows the derivation of seven threshold increments from the sample demonstrator data of Table P-1.

TABLE P-4. DETERMINATION OF THRESHOLD

Maximum Response Stage Value	12.679
Minimum Response Stage Value	0.649
No. increments (variable)	7.000
Threshold Increment	1.7186

b. At each threshold increment the following are calculated:

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (# of response-stage detections)/(# of emplaced ordnance).

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (# of response-stage false positives)/(# of emplaced clutter items).

Response Stage Probability of Background Alarm (P_{ba}^{res}): P_{ba}^{res} = (# of response-stage background alarms)/(# of empty grid locations).

Note that the quantities P_d^{res}, P_{fp}^{res}, and P_{ba}^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. Table P-5 continues the example and shows how ROC curve quantities are calculated for the sample demonstrator data of Table P-1 using the threshold increment determined in Table P-4. Sample ROC curves are plotted in Figures P-2 and P-3.

TABLE P-5. EXAMPLE BLIND GRID RESPONSE STAGE ROC CURVE CALCULATIONS

		Increment	1	2	3	4	5	6	7
		Threshold	0.649	1.7186	3.4371	5.1557	6.8743	8.5929	10.311
			Result = 1 if Response >= Threshold_{inc}; 0 otherwise						
Item	Ground Truth	RESPONSE	RESULT						
1	C	0.649	1	0	0	0	0	0	0
2	O	2.852	1	1	0	0	0	0	0
3	O	8.209	1	1	1	1	1	0	0
4	B	1.757	1	1	0	0	0	0	0
5	B	5.491	1	1	1	1	0	0	0
6	O	9.98	1	1	1	1	1	1	0
7	C	12.679	1	1	1	1	1	1	1
8	C	0.649	1	0	0	0	0	0	0
9	O	2.852	1	1	0	0	0	0	0
Ground Truth Summary:		COUNTS							
# ordnance	4	# detections	4	4	2	2	2	1	0
#fp opportunities	3	# fp	3	1	1	1	1	1	1
#ba opportunities	2	# ba	2	1	1	1	0	0	0
		P_d^{res}	1.0	1.0	0.5	0.5	0.5	0.25	0.0
		P_{fp}^{res}	1.0	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333
		P_{ba}^{res}	1.0	0.5	0.5	0.5	0.0	0.0	0.0

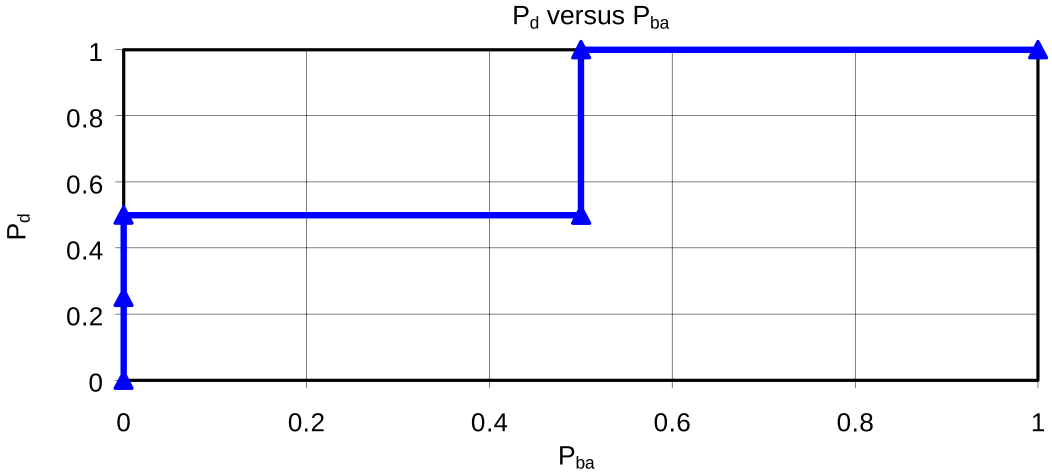


Figure P-2. Blind grid response stage ROC curve.

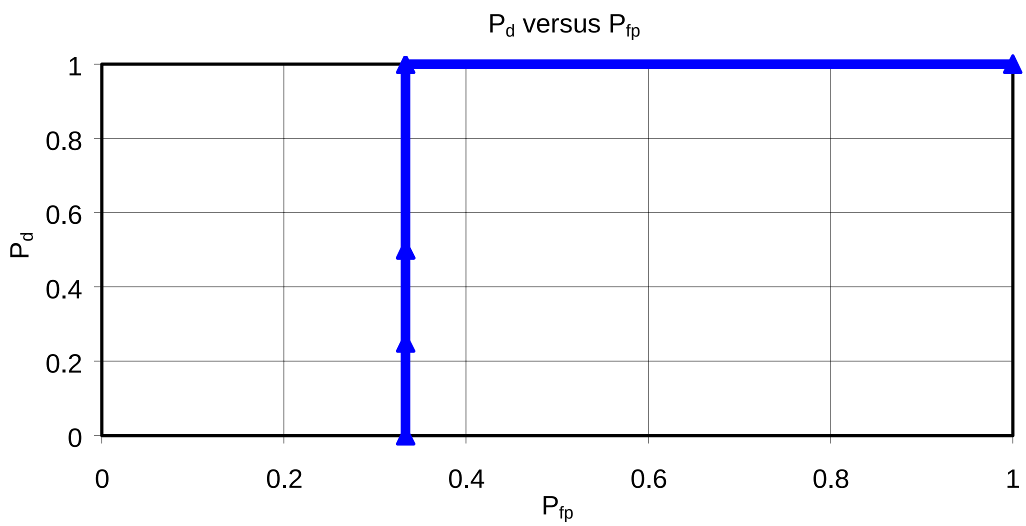


Figure P-3. Blind grid response stage ROC curve.

b. In order to protect the Standardized UXO Test Site ground truth, probabilities and rates will be reported as rounded figures and ROC curves will be smoothed.

3.1.3 Development of ROC Curves - Discrimination Stage

a. In the discrimination stage, the demonstrator's data is already linked by grid location to the ground truth database. Similar to the response stage, the computer program thresholds the demonstrator discrimination data and compares the results to ground truth. The threshold increment is determined by dividing the range (maximum - minimum) of discrimination stage values into a desired number of increments, independent of the number of increments used in the response stage. Table P-6 shows the creation of eight threshold increments, each of size 6.5, from the sample demonstrator data of Table P-1.

TABLE P-6. DETERMINATION OF THRESHOLD

Maximum Discrimination Stage Value	52
Minimum Discrimination Stage Value	0
No. increments (variable)	8
Threshold Increment	6.5

b. At each threshold increment, as well as at the demonstrator’s recommended optimum level, the following are calculated:

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (# of discrimination-stage detections)/(# of emplaced ordnance).

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (# of fp^{disc})/(# of emplaced clutter items).

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (# of BA^{disc})/(# of empty grid locations).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, and P_{ba}^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage value. Table P-7 shows how discrimination-stage ROC curve quantities are calculated for the sample demonstrator data of Table P-1 using the threshold increment determined in Table P-6. Sample ROC curves are plotted in Figures P-4 and P-5.

TABLE P-7. EXAMPLE BLIND GRID DISCRIMINATION STAGE ROC CURVE CALCULATIONS

		Increment	1	2	3	*	4	5	6	7	8
		Threshold	0	6.5	13	15	19.5	26	32.5	39	45.5
	Ground		Result = 1 if Discrimination >= $Threshold_{inc}$; 0 otherwise								
Item	Truth	DISCRIMINATION	RESULT								
1	C	2	1	0	0	0	0	0	0	0	0
2	O	5	1	0	0	0	0	0	0	0	0
3	O	33	1	1	1	1	1	1	1	0	0
4	B	9	1	1	0	0	0	0	0	0	0
5	B	0	1	0	0	0	0	0	0	0	0
6	O	52	1	1	1	1	1	1	1	1	1
7	C	8	1	1	0	0	0	0	0	0	0
8	C	7	1	1	0	0	0	0	0	0	0
9	O	14	1	1	1	0	0	0	0	0	0
Ground Truth Summary:			COUNTS								
# ordnance	4	# detections	4	3	3	2	2	2	2	1	1
#fp opportunities	3	# fp	3	2	0	0	0	0	0	0	0
#ba opportunities	2	# ba	2	1	0	0	0	0	0	0	0
		P_d^{disc}	1	0.75	0.75	0.5	0.5	0.5	0.5	0.25	0.25
		P_{fp}^{disc}	1	0.6667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		P_{ba}^{disc}	1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* = Demonstrator's recommended threshold level.

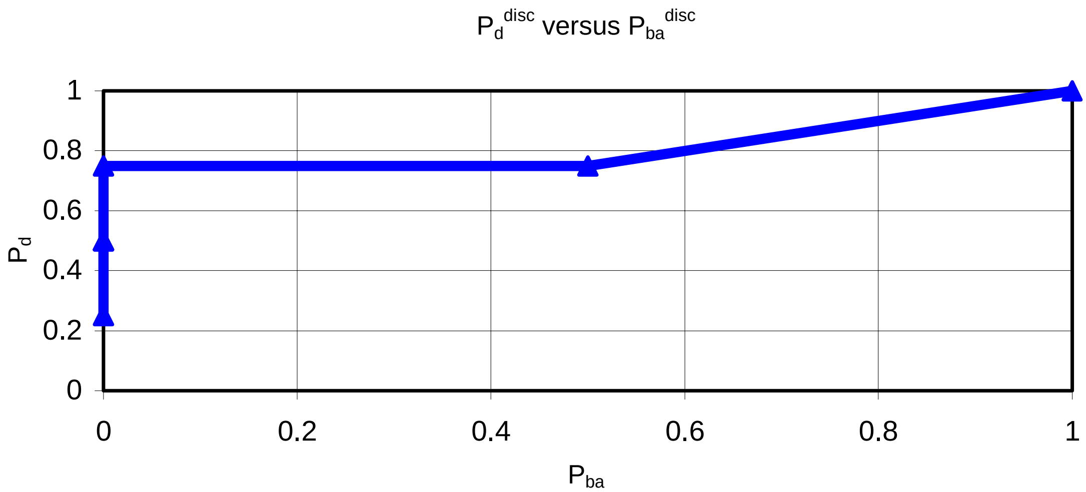


Figure P-4. Blind grid discrimination stage ROC curve.

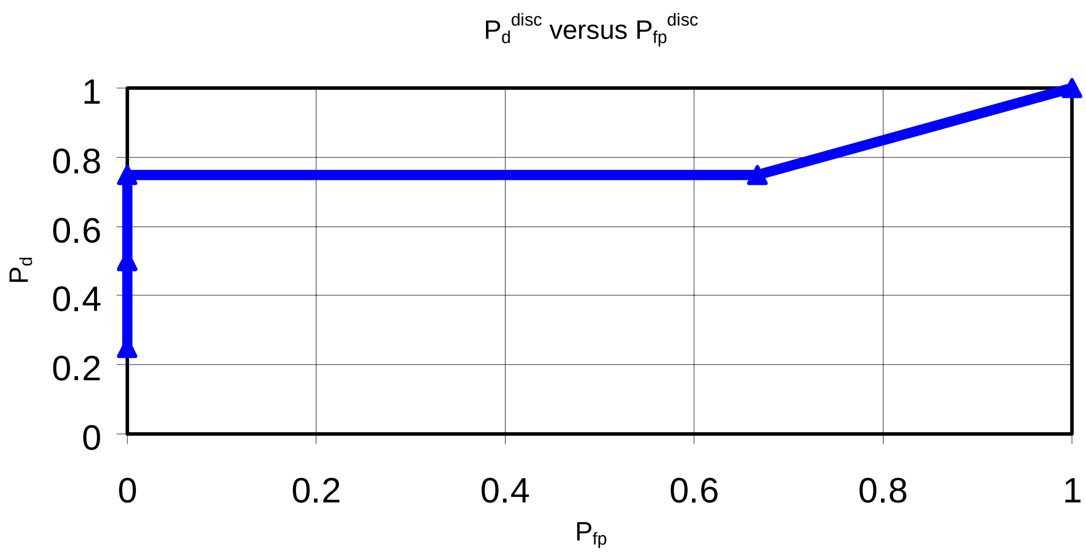


Figure P-5. Blind grid discrimination stage ROC curve.

3.1.4 Other Blind Grid Performance Metrics

- Type Classification: If the demonstrator correctly identifies the item as ordnance, what type is it? The demonstrator will be graded on the ability to correctly identify the type. Table P-8 shows the standardized abbreviations demonstrators must use to classify ordnance. Percent correct will be reported relative to total emplaced ordnance.

TABLE P-8. ABBREVIATIONS FOR TYPE CLASSIFICATIONS

Ordnance	Type	Ordnance	Type
20-mm Projectile	20-mm	40-mm Grenades	40-mm
MK 118 ROCKEYE	MK118	M42 Submunition	M42
BLU-26 Submunition	BLU26	BDU-28 Submunition	BDU28
2.75-in. Rocket	2.75R	57-mm Projectile APC	57-mm
60-mm Mortar	60-mm	81-mm Mortar	81-mm
105-mm Projectile	105-mm P	105-mm Heat Rounds	105-mm
155-mm Projectile	155-mm		

- Location Accuracy: How accurate was the demonstrator in estimating depth? Depth accuracy will be assessed when the demonstrator correctly identifies the detected item as ordnance. Miss distances will be calculated for each ordnance item detected. The average and standard deviation will be reported. To estimate the miss distance for depth the following formula will be used:

$\text{depth} = \text{depth}_{(\text{demonstrator data})} - \text{depth}_{(\text{ground truth})}$.
depth = 0.7 5 meters - 0.86 meters = 0.11 meters.

- Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum achieved detection performance of the sensor system (as determined by the response stage t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

- False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage t_{min}). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

- Background Alarm Rejection Rate (R_{ba}): $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$); Measures the degree to which the discrimination stage correctly rejects false alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all false alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

- Evaluate P_ds for response and discrimination stage performance by depth (shallow, medium, deep), size (small, medium, large), standard versus non-standard ordnance, and overall at the demonstrator's recommended operating level.

3.2 Open Field.

a. The open field is designed to test entire systems (sensors, algorithms, navigation, and delivery platforms). The demonstrator first must locate potential targets and report the locations in GPS coordinates. The open field scoring is similar to the blind test grid scoring in that the demonstrator's list of response stage and discrimination stage outputs are compared to the ground truth. The data collected by the demonstrator is submitted to the scoring committee in the required format.

b. A computer program compares the demonstrator data to the ground truth database. The program links the ground truth database to the demonstrator's data by matching the northing and easting of the ground truth target items to the demonstrator's data. A halo placed around each target will be used to determine a hit. For all clutter items and ordnance items less than or equal to 0.5 meter in length, a circular halo 0.5 meter in radius will be placed around the center of the object. For ordnance items longer than 0.5 meter, the halo becomes an ellipse where the minor axis remains 0.5 meter and the major axis is equal to the half-length of the ordnance plus 0.5 meter. See Figure P-6 for an example. In order for a demonstrator's position data to be linked with a ground truth target item, both the northing and easting of the point must fall within the halo of the emplaced item. See Figure P-7 for an example.

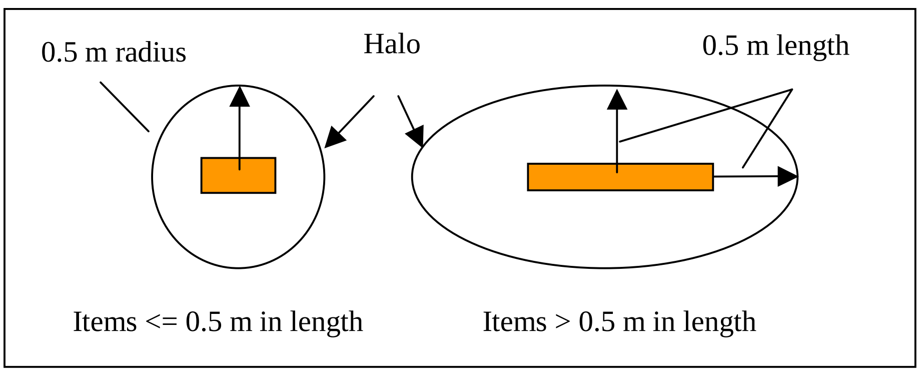


Figure P-6. Target halo.

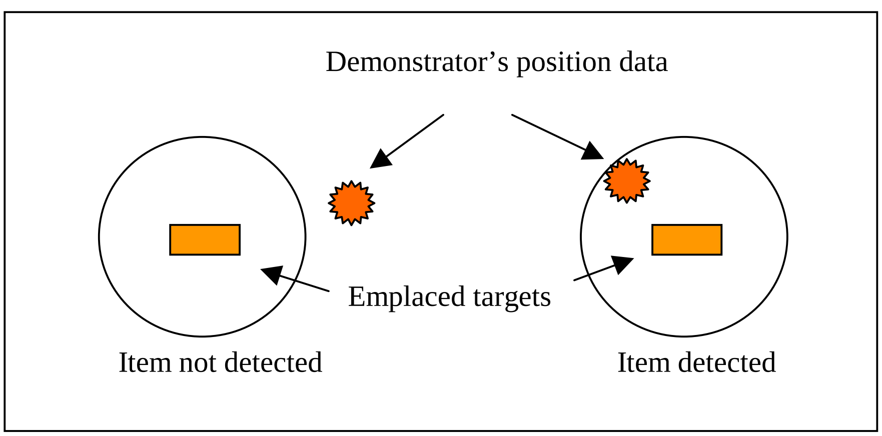


Figure P-7. Position data linked with a target item.

3.2.1 Open Field Scoring Example.

a. Table P-9 is an example of the demonstrator's data in the required format. Table P-10 is an example of hypothetical ground truth data.

TABLE P-9. DEMONSTRATOR DATA FOR OPEN FIELD

	Northing	Easting	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
1	14335954.199	1322776.633	0.649	1	C	-	-	-	-
2	14335810.367	1322622.601	2.852	76	O	20-mm	1.72	142	-69
3	14335769.762	1322340.390	8.209	86	O	105-mm	0.86	16	-52
4	14335723.967	1322372.103	1.757	20	C	-	-	-	-
5	14335667.810	1322381.450	2.491	30	C	-	-	-	-
6	14335714.742	1322349.430	9.980	89	O	105-mm	0.37	140	40
7	14336053.613	1322595.982	12.679	15	O	105-mm	0.28	137	70
8	14335753.177	1322308.994	0.649	40	C	-	-	-	-
9	14335919.549	1322538.777	2.852	52	O	81-mm	1.03	297	- 7

TABLE P-10. HYPOTHETICAL OPEN FIELD GROUND TRUTH DATA

	Northing	Easting	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
101	14335954.399	1322776.533	C	-	-	-	-
102	14335810.267	1322622.501	O	20-mm	1.72	142	-69
103	14335770.862	1322340.290	O	105-mm	0.86	16	-52
104	14335723.867	1322372.153	C	-	-	-	-
105	14335667.910	1322381.300	C	-	-	-	-
106	14335714.842	1322349.533	O	105-mm	0.37	140	40
107	14336053.513	1322595.982	O	105-mm	0.28	137	70
108	14335753.277	1322309.294	C	-	-	-	-
109	14335919.449	1322538.377	O	81-mm	0.96	310	-10

b. Table P-11 is an example of the computer program linking the two data sets for the demonstrator's point 9 only. To establish a link between the two data sets, the distance formula is used to calculate the radial distance, r, between a demonstrator point (dd) and a ground truth location (gt). This equation is:

$$r = ((\text{northing}_{(gt)} - \text{northing}_{(dd)})^2 + (\text{easting}_{(gt)} - \text{easting}_{(dd)})^2)^{1/2}.$$
$$r = ((14335919.449 - 14335919.549)^2 + (1322538.377 - 1322538.777)^{2})^{1/2}.$$
$$r = 0.412 \text{ meter.}$$

Since r is less than 0.5 meter, the demonstrator's point 9 will be linked only with this ground truth item. Demonstrator data not linked to items in the ground truth database will be scored as background alarms. Note in the example data sets above that demonstrator's point 3 is

not within 0.5 meter of any item in the ground truth. Demonstrator's point 3 will be scored as a background alarm. In the case of multiple hits within the same halo, the demonstrator data with the strongest signal will be linked to the ground truth item. The remaining hits in that halo will be disregarded.

TABLE P-11. COMPUTER PROGRAM LINKING GPS LOCATIONS

	Northing	Easting	Response Stage	Discrimination Stage/ Ranking	Classification	Type	Depth, m	Azimuth, deg	Dip, deg
Demonstrator's Data (dd)									
9	14335919.549	1322538.777	2.852	52	O	81-mm	1.03	297	- 7
Ground Truth Data (gt)									
109	14335919.449	1322538.377	-	-	O	81-mm	0.96	310	-10

3.2.2 Development of ROC Curves - Response Stage

a. After linking the demonstrator data to the ground truth database the program thresholds the demonstrator response data. The threshold increment is determined in the same way for the open field as for the blind grid (see table P-4 for an example).

b. At each threshold increment the following are calculated:

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (# of response-stage detections)/(# of emplaced ordnance).

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (# of response-stage false positives)/(# of emplaced clutter items).

Response Stage Background Alarm Rate (BAR^{res}): BAR^{res} = (# of response-stage background alarms)/arbitrary constant.

Note that the quantities P_d^{res}, P_{fp}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. Table P-12 continues the example and shows how ROC curve quantities are calculated for the sample demonstrator data of Table P-9. (The threshold increment determined in table P-4 applies.) Sample ROC curves are plotted in Figures P-6 and P-7.

TABLE P-12. EXAMPLE OPEN FIELD RESPONSE STAGE ROC CURVE CALCULATIONS

Linked Demo/GT	Ground Truth	Bin No.	1	2	3	4	5	6	7
		Threshold	0.649	2.406	4.812	7.218	9.624	12.03	14.436
			Result = 1 if Response >= Threshold$_{bin}$; 0 otherwise						
		RESPONSE	RESULT						
1/101	C	0.649	1	0	0	0	0	0	0
2/102	O	2.852	1	1	0	0	0	0	0
4/104	C	1.757	1	0	0	0	0	0	0
5/105	C	2.491	1	1	0	0	0	0	0
6/106	O	9.98	1	1	1	1	1	0	0
7/107	O	12.679	1	1	1	1	1	1	0
8/108	C	0.649	1	0	0	0	0	0	0
9/109	O	2.852	1	1	0	0	0	0	0
NOT Linked									
3/NA		8.209	1	1	1	1	0	0	0
NA/103	O	-	-	-	-	-	-	-	-
Ground Truth Summary:			COUNTS						
# ordnance	5	# detections	4.0	4.0	2.0	2.0	2.0	2.0	1.0
# emplaced Clutter	4	# fp	4.0	1.0	0.0	0.0	0.0	0.0	0.0
		# ba	1.0	1.0	1.0	1.0	0.0	0.0	0.0
		P_d^{res}	0.8	0.8	0.4	0.4	0.4	0.4	0.2
		P_{fp}^{res}	1.0	0.25	0.0	0.0	0.0	0.0	0.0
		BAR^{res}	0.05	0.05	0.05	0.05	0.0	0.0	0.0

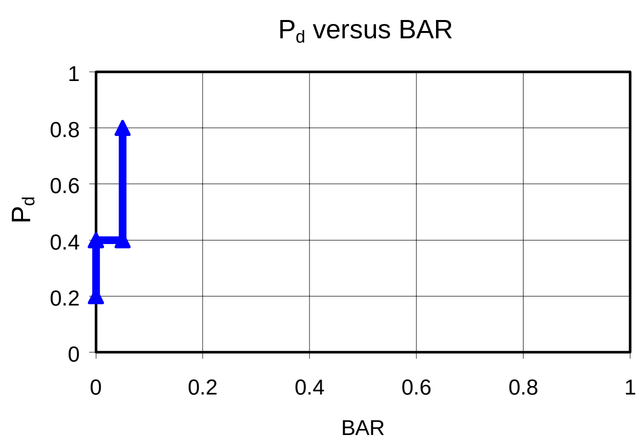


Figure P-6. Open field response stage.

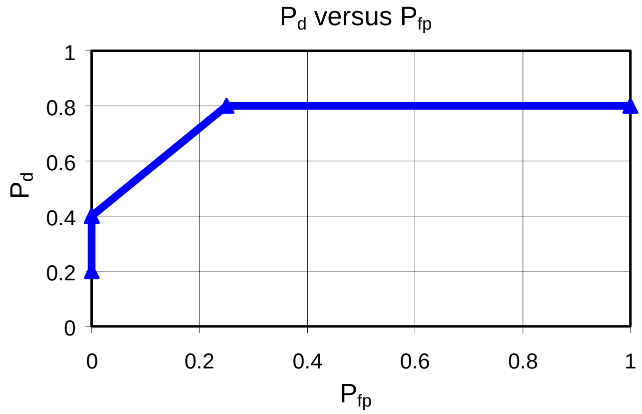


Figure P-7. Open field response stage ROC curve.

c. In order to protect the Standardized UXO Test Site ground truth, probabilities and rates will be reported as rounded figures and ROC curves will be smoothed.

3.2.3 Development of ROC Curves - Discrimination Stage

a. Using the same links between demonstrator and ground truth data sets, the program thresholds the demonstrator's discrimination data. The threshold increment is determined by dividing the range (maximum - minimum) of discrimination stage values into a desired number of increments, independent of the number of increments used in the response stage.

b. At each threshold increment and at the demonstrator's recommended level, the following will be calculated:

<u>Discrimination Stage Probability of Detection</u> (P_d^{disc}): P_d^{disc} = (# of discrimination-stage detections)/(# of emplaced ordnance in the test site).

<u>Discrimination Stage Probability of False Positive</u> (P_{fp}^{disc}): P_{fp}^{disc} = (# of fp^{disc})/(# of emplaced clutter items).

<u>Discrimination Stage Background Alarm Rate</u> (BAR^{disc}): BAR^{disc} = (# of BA^{disc})/(test area).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. Table P-13 continues the example and shows how ROC curve quantities are calculated for the sample demonstrator data of Table P-9 using ground truth data in Table P-10. Sample ROC curves are plotted in Figures P-8 and P-9.

TABLE 13. EXAMPLE OPEN FIELD RESPONSE STAGE ROC CURVE CALCULATIONS

		Bin No.	1	2	*	3	4	5	6	7	8
		Threshold	1	14.667	15	29.333	44	58.667	73.333	88	102.67
Linked	Ground		Result = 1 if Discrimination >= Threshold_{bin}; 0 otherwise								
Demo/GT	Truth	DISCRIMINATION	RESULT								
1/101	C	1	1	0	0	0	0	0	0	0	0
2/102	O	76	1	1	1	1	1	1	1	0	0
4/104	C	20	1	1	1	0	0	0	0	0	0
5/105	C	30	1	1	1	1	0	0	0	0	0
6/106	O	89	1	1	1	1	1	1	1	1	0
7/107	O	15	1	1	1	0	0	0	0	0	0
8/108	C	40	1	1	1	1	0	0	0	0	0
9/109	O	52	1	1	1	1	1	0	0	0	0
NOT Linked											
3/NA		86	1	1	1	1	1	1	1	0	0
NA/103	O	-	-	-	-	-	-	-	-	-	-
Ground Truth Summary:			COUNTS								
# ordnance	5	# detections	4.0	4.0	3.0	2.0	2.0	2.0	2.0	1.0	0.0
# emplaced		# fp	4.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
clutter	4	# ba	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0
		P_d^{disc}	0.8	0.8	0.6	0.4	0.4	0.4	0.4	0.2	0.0
		P_{fp}^{disc}	1.0	0.75	0.5	0.0	0.0	0.0	0.0	0.0	0.0
		BAR^{disc}	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.0	0.0

* Demonstrator's recommended threshold level.

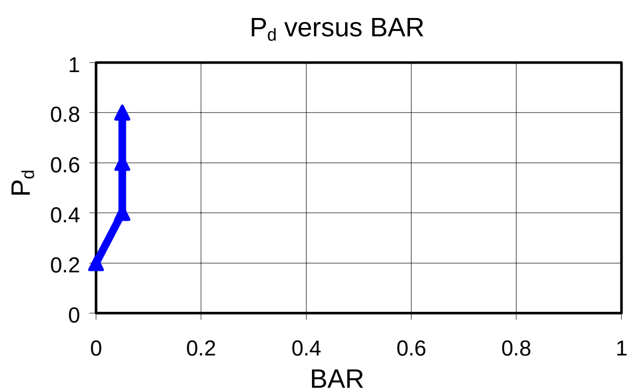


Figure P-8.   Open field discrimination stage ROC curve.

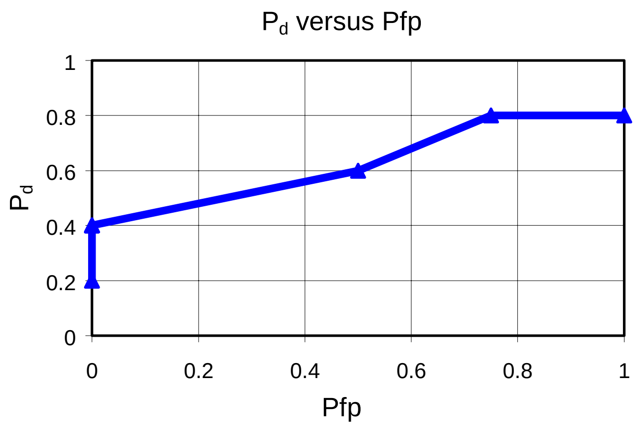


Figure P-9. Open field discrimination stage ROC curve.

3.2.4 Other Open Field Performance Metrics

- Type Classification: If the demonstrator correctly classified the item as ordnance, what type is it? The demonstrator will be graded on the ability to correctly identify the type. Table P-8 shows the abbreviations used to identify ordnance. The demonstrator's point 9 (see Table 11) will be scored as a correct type classification.

- Location Accuracy: How accurate was the demonstrator in estimating depth and ordnance location? Location accuracy will be assessed for those items correctly identified as ordnance. Unidirectional linear miss distances (northing, easting, and depth) will be calculated for each ordnance item detected. The average and standard deviation will be reported for each direction. To calculate miss distance for depth and location accuracy, the following formulas will be used:

  $\text{depth} = \text{depth}_{(dd)} - \text{depth}_{(gt)}$
  depth = 1.03 meter - 0.96 meter = 0.07 meter.

  $\text{northing} = \text{northing}_{(dd)} - \text{northing}_{(gt)}$
  northing = 14335919.449 - 14335919.802 = -0.353 meter.

  $\text{easting} = \text{easting}_{(dd)} - \text{easting}_{(gt)}$
  easting = 1322538.377 + 1322538.602 = -0.232 meter.

- Efficiency (E): $E = P_{det}^{disc}(t^{disc})/P_{det}^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

- False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage t_{min}). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

- Background Alarm Rejection Rate (R_{BA}): $R_{BA} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})]$; Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

- Evaluate P_ds for response and discrimination stage performance by depth (shallow, medium, deep), size (small, medium, large), standard versus nonstandard ordnance, and overall at the demonstrator's recommended operating level. Lower 90 percent binomial confidence limits will be calculated for P_d^{res}, P_{fp}^{res}, P_d^{disc}, and P_{fp}^{disc}.

4. Comparisons Between Test Scenarios

Statistical significance tests are used to compare results between test scenarios (Blind Grid, Open Field, Scenario 1, and Scenario 2) or with past performance. The intent of the comparison is to determine if the feature introduced in each scenario has a degrading effect on the performance of the sensor system. However, any modifications in the UXO sensor system under test, like changes in the processing or changes in the selection of the operating threshold, will also contribute to performance differences. The Chi-square test for comparison between ratios will be used at a significance level of 0.05 to compare probabilities of detection, probabilities of false positive, efficiency rates, and rejection ratios between test scenarios. Example comparisons between Blind Test Grid and Open Field results are presented in Tables P-14 and P-15.

TABLE P-14. CHI-SQUARE COMPARISON RESULTS, BLIND TEST GRID COMPARED TO OPEN FIELD

	Small	Medium	Large	Overall
P_{det}^{disc}	Sig	Not Sig	Not Sig	Not Sig
P_{fp}^{disc}	Sig	Not Sig	Not Sig	Not Sig

Sig = Significant.

It can be seen from the comparison results that the system's ability to detect small caliber ordnance was significantly reduced in Open Field as compared to its performance in the Blind Test Grid.

TABLE P-15. CHI-SQUARE COMPARISON RESULTS, BLIND TEST GRID COMPARED TO OPEN FIELD

	Small	Medium	Large	Overall
Efficiency	Sig	Not Sig	Not Sig	Not Sig
Rejection Ratio	Sig	Not Sig	Not Sig	Not Sig

The significant difference between efficiencies indicates that detected small caliber items were not correctly identified as ordnance as often in Open Field as they were in the Blind Test Grid.

5. Cost, Time and Manpower Requirements.

Cost, time and manpower requirements will capture field labor costs associated with conducting a field survey. In order for standardized labor costs to be applied among all demonstrators, set labor rates have been established for three labor categories: supervisor, data analyst, and field support. Labor costs will be calculated as follows: The first person at the test site will be designated supervisor; the second person will be designated data analyst; third and following personnel will each be regarded as field support. Labor will be monitored by government on-site representatives on a man-hour basis and will be converted to cost by the application of standardized labor rates as presented in Table P-16. Labor costs include time associated with setup and calibration of equipment, surveying blind test grid, open field and/or scenarios, and demobilization. The labor costs associated with the calibration lanes will not be recorded.

TABLE P-16. LABOR COSTS

Setup and Calibration of Equipment	No. People	Hourly Wage	Hours	Cost
Supervisor	1	$95.00	16	$ 1,520
Data Analyst	1	57.00	16	912
Field Support	4	28.50	16	1,824
Subtotal	6	-	96	4,256
Blind Test Grid				
Supervisor	1	95.00	10	950
Data Analyst	1	57.00	10	570
Field Support	4	28.50	10	1,140
Subtotal	6	-	60	2,660
Open Field				
Supervisor	1	95.00	24	2,280
Data Analyst	1	57.00	24	1,368
Field Support	3	28.50	24	2,052
Subtotal	5	-	120	5,700
Demobilization				
Supervisor	1	95.00	6	570
Data Analyst	0	57.00	0	0
Field Support	3	28.50	6	513
Subtotal	4	-	24	1,083
Total	-	-	300	$13,699

APPENDIX Q. GLOSSARY OF TERMS

Anomaly	Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.
Azimuth	Positive clockwise direction of the ordnance nose from magnetic North.
BA^{disc}	A discrimination-stage location outside R_{halo} of any emplaced ordnance or emplaced clutter item.
BAR^{disc}	= (# of BA^{disc})/(test area).
BA^{res}	An anomaly from the response stage outside R_{halo} of any emplaced ordnance or emplaced clutter item.
BAR^{res}	= (# of BA^{res})/(test area).
Blind Test Grid	A matrix of squares. Center of each grid block may be a target, a piece of clutter, or nothing to test demonstrator detection system performance.
Calibration Lane	Contains targets from the standardized target list at 7 primary orientations to allow the demonstrator to develop a library on his detection system performance against known targets and location.
Clutter	Clutter items may include fragments of military munitions which have functioned as designed or were recovered from areas where munitions have been intentionally destroyed and have no explosive, pyrotechnic or chemical filler; steel; aluminum; magnetic rock; or copper.
Degaussing	Removing any remnant magnetic moments from ordnance targets.
Demonstrator	Vendor, user, developer of UXO detection and discrimination technologies.
Detection	An anomaly location that is within R_{halo} of an emplaced ordnance item.
Dip	Angle of inclination; Nose up (+), Nose down (-).
Discrimination	The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter.

Discrimination Stage	The ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly column, the DISCRIMINATION STAGE column contains the output of the algorithms applied in the discrimination-stage processing. This column is prioritized based on the determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that provides optimum system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).
Efficiency (E)	$= P_{det}^{disc}(t^{disc})/P_{det}^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.
Emplaced Clutter	A clutter item (i.e., nonordnance item) buried by the government at a specified location in the test site.
Emplaced Ordnance	An inert ordnance item buried by the government at a specified location in the test site.
FAR	False identification of target in a empty grid cell.
FAR^{res}	= (# of BA^{res})/(# of opportunities).
fp^{disc}	A discrimination-stage location within R_{halo} of an emplaced clutter item.
fp^{res}	An anomaly location that is within R_{halo} of an emplaced clutter item.
Large Ordnance	Caliber of ordnance greater than 81-mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-lb bomb).
Medium Ordnance	Caliber of ordnance greater than 40-mm and less than or equal to 81-mm (includes 57-mm projectile, 60-mm mortar, 2.75-inch Rocket, MK 118 Rockeye, 81-mm mortar).

NAD83 Datum — Expressed as an Easting/Northing UTM number.

Open Field Site — Minimum 4 hectares site with a myriad of clutter, range simulations, and targets to test demonstrator detection system performance under real field-type conditions.

P_{ba}^{disc} — = (# of BA^{disc})/(# of empty grid locations).

P_{det}^{disc} — = (# of discrimination-stage detections)/(# of emplaced ordnance in the test site).

$\underline{P_{det}^{res}}$ — = (# of response-stage detections)/(# of emplaced ordnance in the test site).

P_{fp}^{res} — = (# of response-stage false positives)/(# of emplaced clutter items).

R_{BA} — $= 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})]$; Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

R_{fp} — $= 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

R_{halo} — A predetermined radius about the center of the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} is utilized.

Raw Sensor Data — Preprocessed or minimally processed data for each grid square or open field area.

Response Stage	The ability of the demonstrator's system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. The RESPONSE STAGE provides the location and signal strength of all anomalies deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.
ROC Curve	Receiver Operating Characteristic curve provides the only useful and valid means of comparing performance among sensor/algorithm combinations and for determining the efficacy of algorithm or technology advancements.
Small Ordnance	Caliber of ordnance less than or equal to 40-mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BDU-28, and M42).
Standardized Site	Made up of three areas - Calibration Lanes/Ground Test Pit, a Blind Test Grid, and an Open Field Site designed to test the demonstrator detection systems under various test parameters.
Standardized Target	A military munition which contains no energetic material. These items pose no imminent threat. However, will remain under the control of the Standardized UXO Technology Demonstration Site On-Site Project Manager as issued by the ATC Project Manager.
Threshold	The limit, set on a system's discrimination stage, which defines the difference between what is considered to be ordnance and what is considered nonordnance. Only those signals that exceed (or fall below, depending on the signal strength polarity) the threshold are considered to result from ordnance.
Target Repository	Located at Aberdeen Proving Ground, MD. Managed by the ATC Target Repository Standardized UXO Technology Demonstration Site Program Manager. Thirteen types of standardized targets are available for loan.

Unexploded Ordnance (UXO)	A military munition that contains explosive or pyrotechnic charge and has been primed, fuzed, armed or otherwise prepared for action and which has been fired, placed, dropped, launched or projected, and remains unexploded by design or malfunction. An item of explosive ordnance which has failed to function as designed or has been abandoned, discarded or improperly disposed of and is still capable of functioning, causing damage to personnel or material. These can be, but are not limited to high-explosive warheads, rocket motors, practice munitions with spotting charges, torpedoes, artillery and mortar ammunition, grenades, incendiary munitions, electro-explosive devices and propellant-actuated devices. Fuzes with live explosive boosters or detonators are classified as UXO. All UXO are potentially dangerous and cannot be released for public use without being rendered safe (neutralized, vented, detonated, decontaminated or demilitarized).

APPENDIX R. ABBREVIATIONS

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A1	=	aluminum
AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ASTM	=	American Society for Testing and Materials
AT/FP	=	antiterrorism/force protection
ATC	=	U.S. Army Aberdeen Test Center
B	=	Blind Test Grid
BA	=	background alarm
BA^{disc}	=	discrimination stage background alarm
BAR	=	background alarm rate
BAR^{disc}	=	discrimination stage background alarm rate
BA^{res}	=	response stage background alarm
BAR^{res}	=	response stage background alarm rate
Br	=	Brass
CAL	=	Calibration Lanes
CGS	=	Coastal Geodetic Survey
CL	=	clutter
CORPS	=	Corps of Engineers
Cu	=	copper
DA	=	Department of the Army
DAQ	=	data acquisition
DAS	=	data acquisition system
DDD.MM	=	Degree. Decimal Minutes
DDESB	=	Department of Defense Explosives Safety Board
det	=	detection
DGPS	=	Differential Global Positioning System
disc	=	discrimination
DOD	=	Department of Defense
DTEM	=	Digital Terrain/Elevation Model
DUSD	=	Deputy Under Secretary of Defense
E	=	efficiency
EK	=	Elkton Silt Loam
EM	=	electromagnetic
EMI	=	electromagnetic interference
EOD	=	explosive ordnance disposal
ERDC	=	Engineer Research and Development Center
ES	=	Environmental Security
ESTCP	=	Environmental Security Technology Certification Program
FAR	=	false alarm rate
FAR^{disc}	=	discrimination stage false alarm
FAR^{res}	=	response stage false alarm rate
FM	=	frequency modulation
fp	=	false positive
FPCON	=	force protection conditions
fp^{disc}	=	discrimination stage false positive

FPO	=	Force Protection Officer
FPR	=	Force Protection Representative
fp^{res}	=	response stage false positive
GIS	=	Geographical Information System
GPR	=	ground-penetrating radar
GPS	=	Global Positioning System
H	=	inert explosive filled round
HSP	=	Health and Safety Plan
ID	=	identification
JHA	=	Job Hazard Analysis
JPG	=	U.S. Army Jefferson Proving Ground
JUXOCO	=	Joint Unexploded Ordnance Coordination Office
m/Bar	=	milli-Bars
MAGR	=	magnetic rock
mm	=	millimeter
MMR	=	Massachusetts Military Reservation
MOA	=	Memorandum of Agreement
MOU	=	Memorandum of Understanding
MpA	=	Mattapex Silt Loam
ms/m	=	millisiemen per meter
mT	=	mTesla
MTADS	=	multisensor towed array detection system
mV	=	millivolts
NAD	=	North American Datum
NEPA	=	National Environment Policy Act
NGS	=	National Geodetic Survey
NRL	=	Naval Research Laboratory
NS	=	nonstandard
nT	=	nanoTesla
OF	=	Open Field Site
OR	=	inert ordnance
OSD	=	Office of the Secretary of Defense
OSHA	=	Occupation Safety and Health Administration
P	=	probability, projectile
P_{ba}^{disc}	=	discrimination stage probability background alarm
P_d	=	probability of detection
P_{det}^{disc}	=	discrimination stage probability of detection
P_{det}^{res}	=	response stage probability of detection
P_{fa}	=	probability of false alarm
P_{fp}	=	false positive
P_{fp}^{disc}	=	discrimination stage probability of false positive
P_{fp}^{res}	=	response stage probability of false positive
PL	=	plastic
PM	=	Program Manager

POC	=	point of contact
ppt	=	part per thousand

PVC	=	polyvinylchloride
QA	=	quality assurance
QC	=	quality control
R_{BA}	=	background alarm rejection rate
RDT&E	=	research, development, test and evaluation
RF	=	radio frequency
R_{fp}	=	false positive rejection rate
RoA	=	Romney Silt Loam
ROC	=	receiver-operating characteristic
RTK	=	real time kinematic
Rx	=	receiver
SERDP	=	Strategic Environmental Research and Development Program
SOP	=	Standard Operating Procedure
St	=	steel
SUXOTDS	=	Standardized UXO Technology Demonstration Site
t^{dics}	=	discrimination threshold
TDR	=	Time Domain Reflectometry
t_{max}	=	maximum threshold
t_{min}	=	minimum threshold
t_{min}^{res}	=	response stage minimize threshold
Tx	=	transmitter
USAR	=	U.S. Army Reserves
USGS	=	U.S. Geological Survey
UTC	=	Universal Time Coordinated
UTM	=	Universal Transverse Mercator
UXO	=	unexploded ordnance
VES	=	vertical electrical resistivity soundings
W	=	wood
W/msq	=	watts per square meter
WES	=	Waterways Experiment Station
WP	=	work plan
YPG	=	U.S. Army Yuma Proving Ground

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